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(54) MEDICINAL COMPOSITIONS PROMOTING BOWEL MOVEMENT

MEDIZINISCHE ZUSAMMENSETZUNGEN ZUR FÖRDERUNG DER AKTIVIERUNG DER
EINGEWEIDE

COMPOSITIONS MEDICINALES FAVORISANT LES MOUVEMENTS INTESTINAUX

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Description

Technical Field

[0001] The present invention relates to a novel pharmaceutical composition, and to a novel pyrimidine compound or a salt thereof, as well as uses of this compound for the manufacture of a pharmaceutical composition for promotion of defecation and for treating, preventing or improving constipation.

Prior Art

[0002] Constipation refers to a condition where defecation is difficult or rare, and this is a well-known disease. Known constipation is divided mainly into e.g. functional constipation (acute constipation and various kinds of chronic constipation (for example, atonic constipation, spastic constipation, dyschezia, rectal constipation, chemically inducible constipation etc.)), organic constipation, enteroparalytic ileus, IBS, constipation accompanying IBS, constipation accompanying congenital digestive tract dysfunction, constipation accompanying ileus etc. In defecation in the normal state, stimulation of rectal mucous with intestinal contents transferred to the rectum is transmitted to the central nerve, thus inducing an inclination for the stool while causing the bowels and muscles to be reflectively relaxed and contracted (defecating reflex), while constipation occurs due to defecating functions ruined by autonomic nervous dysfunction occurred in digestive tracts, hyper-absorption of water into intestinal tracts, a reduction in secretion of intestinal mucus, motility hindrance, digestive psychosomatic disease in the digestive organs (for example, irritable bowel syndrome (IBS), a reduction in defecating reflective functions, etc. Many of these obstacles are caused by eating habits, life-style, physical activity, psychogenic background (mental stress, emotional instability, etc.). Recently, such constipation is a serious problem in the fields of nursing and clinical and medical cure. As one of factors, there is a rapid increasing number of old people in the society in recent years and an increase in old peoples requiring nursing. Patients with constipation (for example, atonic constipation) attributable to autonomous nervous dysfunction are rapidly increasing. Another factor is an increase in diseases readily causing a reduction in the motility function of digestive tracts. In particular, diabetes is one of serious diseases, and is problematic as complications to cause a rapid increase in patients with constipation. This is called symptomatic constipation, and also observed in hypothyroidism, scleroderma, cerebrovascular disturbances, depression, spinal disturbances, electrolyte abnormalities, uremia, interstitial lung disease, pulmonary emphysema and various nerve diseases. In addition to these, there are really many reports on patients with spastic constipation accompanying IBS observed often in youths, on patients with chemically inducible constipation induced by use of morphine in cancer patients, etc.

[0003] Prescriptions such as a laxative and an enema are conventionally used in principal therapeutic methods. However, these chemicals easily cause diarrhea upon administration thereof, give physical and mental suffering to the patients and nurses, and usually require a long time until their action appears, and their action is long-lasting. There is also a problem that overuse of an enema also causes disappearance of an inclination for the stool. Further, when the patient has high blood pressure or may have cerebral apoplexy, cerebral infarction, cardiac infarction etc., there is also the situation where an enema should be used inevitably to prevent such diseases. Accordingly, if there is a medicine gently promoting defecation without generating diarrhea, the medicine can be expected to be very useful and advantageous to many patients and nurses, and there is demand for providing the medicament. However, a medicine satisfactory in these aspects is still not found.

[0004] As to a defecation-promoting agent not causing diarrhea, on one hand, WO94/16702 and Jpn. J. Pharmacol. (68, 119-123 (1995)) have reported "An agent for treating abnormal defection comprising as an active ingredient a xanthine derivative which selectively and antagonistically inhibits adenosine A₁ receptor or a pharmacologically acceptable salt thereof."

[0005] Adenosine is an important regulatory factor involved in many intracellular metabolisms such as regulation of energy levels and cAMP levels in the living body, opening and closing calcium channels, and inflow of calcium ions into cells, and its interaction with adenosine receptors on the surface of a cell is essential for exhibiting these physiological activities. Four kinds of receptor subtypes (A₁, A_{2a}, A_{2b}, A₃) have been identified until now. These subtypes are different from one another in their distribution in tissues; that is, the A₁ receptor occurs relatively abundantly in the heart, aorta, bladder etc., but hardly occurs in the jejunum and in the proximal colon, the A_{2a} receptor is distributed relatively abundantly in the eyeballs, skeletal muscles etc., the A_{2b} receptor in the proximal colon, eyeballs, lung etc., and the A₃ receptor in the spleen, uterus, prostate etc. (Br. J. Pharmacol., 118, 1461-1468 (1996)). Adenosine is involved in various physiological functions such as platelet agglutination, heart beat, contraction of smooth muscles, inflammations, release of neurotransmitters, neurotransmission, release of hormones, cellular differentiation, growth of cells, death of cells, biosynthesis of DNA, etc., thus suggesting the relationship thereof with central nerve diseases, cardiovascular diseases, inflammatory diseases, respiratory diseases, immune diseases etc., so usefulness of adenosine receptor agonists/antagonists against these diseases is expected. In addition to WO94/16702 supra, the rela-

tionship between the adenosine receptors and the intestinal tracts has been reported in e.g. the followings 1) to 5):

1) An agent for treating abnormal acceleration of intestinal motility, which comprises an adenosine derivative or a pharmacologically acceptable salt thereof as an active ingredient (JP-A 6-211669);

2) An adenosine A_1 receptor-selective antagonist brings about a defecation-promoting action by improving the motility of the intestinal tract via release of acetylcholine in neuroterminal distributed in the intestinal tract (Eur. J. Pharmacol., 264, 91 (1994), Gastroenterology, 104, 1420 (1993), Neuroscience, 67, 159 (1995));

3) An adenosine A_2 receptor-selective antagonist had no defecation-promoting action (Jpn. J. Pharmacol., 68, 119-123 (1995), Eur. J. Pharmacol., 64, 91 (1994));

4) Adenosine agonists NECA and CPA were added at 0.1 to 30 μ M to rat distal colon longitudinal muscles contracted by stimulation with Carbachol, whereby relaxation was observed, and this action was exhibited more strongly by NECA than CPA and antagonized by 1 μ M DPCPX as an adenosine antagonist. The pA_2 value (NECA, 6.15 to 6.66; CPA, 6.45 to 6.55) of the antagonistic action of DPCPX suggested that this relaxing action is mediated by A_2 receptor, and this action was not antagonized by 10 μ M CGS21680 (Naunyn-Schmiedeberg's Arch. Pharmacol., 359, 140-146 (1999)); and

5) By adding an adenosine A_1/A_2 agonist NECA or an A_1 agonist CPA to guinea pig distal colon longitudinal muscles contracted by electrical stimulation, relaxation was observed, while the action of an A_{2a} agonist CGS21680 was very weak. Further, the relaxing action of NECA was antagonized by DPCPX as A_1 antagonist and 8-PT as A_1/A_2 antagonist, and the pA_2 value of the antagonistic action of the two and their ratio (DPCPX, 8.8; 8-PT, 6.5) suggested that this relaxing action is mediated via A_1 receptor. Further, NECA or CPA at a concentration (100 nM) enough to relax the contraction of guinea pig colon longitudinal muscles by electrical stimulation did not exhibit a relaxing action on the contracting action of the muscles stimulated by acetylcholine. From the foregoing, it was suggested that the A_1 receptor via which the relaxing action of adenosine on the contraction of guinea pig distal colon longitudinal muscles stimulated by electrical stimulation is mediated, occurs in presynapses at nerve endings and participates in suppression of release of acetylcholine. NECA exhibited a relaxing action (EC_{50} : 10.4 μ M) on the contracting action of guinea pig distal colon longitudinal muscles stimulated with KCl in the presence of tetrodotoxin, while 1 μ M CGS21680 did not act thereon, and

CPA acted thereon at a high concentration (EC_{50} : 12.6 μ M). Further, DPCPX at a concentration (1 nM) enough to selectively inhibit the A_1 receptor did not show an antagonistic action, thus indicating that this relaxing action is not mediated via A_1 receptor. Further, DPCPX at a concentration (10 nM) enough to inhibit the A_{2b} receptor inhibited the relaxing action of NECA and CPA, and comparison between the pA_2 value (NECA; 6.6, CPA; 7.0) in each case and the case (6.6) of DPCPX having the pA_2 value (5.7) upon inhibition of the action of NECA by 10 μ M 8-PT indicated that this inhibitory action is mediated via A_{2b} receptor. These results indicated that the relaxing action of adenosine on the contraction of guinea pig distal colon longitudinal muscles stimulated with KCl in the presence of tetrodotoxin is mediated via the A_{2b} receptor present in the longitudinal muscles. From these experimental results, it was suggested that adenosine exhibits a relaxing action via the two different receptors, that is, A_1 receptor in presynapse and A_{2b} receptor in postsynapse in guinea pig distant colon longitudinal muscles (Br. J. Pharmacol., 129, 871-876 (2000)).

[0006] The xanthine derivative not causing diarrhea described in WO94/16702 supra is reported to exhibit a defecation-promoting action based on an adenosine A_1 receptor antagonism via cholinergic nerves (Eur. J. Pharmacol., 264, 91 (1994)). Accordingly, it is considered as clinical significance if a strong defecation-promoting action can be exhibited via direct action on the digestive tracts. However, the xanthine derivative exhibits a diuretic action based on an adenosine A_1 receptor antagonism (JP-A 3-173889), so its use as a defecation-promoting agent should be significantly limited. This is because assuming its use in patients with complications with renal diseases or old peoples requiring nursing, it is desired that the balance between the diuretic action and defecation-promoting action is shifted toward the defecation-promoting action. From the foregoing, in the treatment of constipation, pharmaceutical preparations promoting defecation gently but strongly without causing diarrhea can be expected to be very useful in patients and nurses. That is, the object of the present invention is to search for and find such medicaments.

Disclosure of the Invention

[0007] The present inventors made extensive study in view of the circumstances described above, and on the basis of literatures on the distribution of adenosine receptors in the intestinal tracts in humans and rats, in which A_{2b} receptor belonging to a subtype of A_2 receptor is reported to occur particularly abundantly in the colon (Mol. Endocrinol., 6, 384 (1992), Mol. Pharmacol., 47, 1126 (1995), Br. J. Pharmacol., 118, 1461 (1996)), they established the following new concepts (I) and (II).

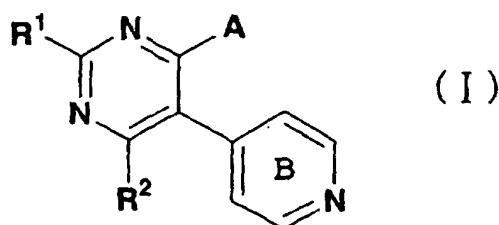
(I) The difference in the distribution of adenosine receptors in the colon is related to the functions of the colon.

That is, the A₂ receptor, particularly A_{2b} receptor, is involved closely in regulation of the functions of the colon.

(II) As for colon motility involved in the defecation, a compound having an adenosine A₂ receptor antagonism, particularly a compound having an A_{2b} receptor antagonism, brings about the action of regulating colon motility via a mechanism different from that of the above-mentioned xanthine derivative (A₁ antagonist).

[0008] Then, the present inventors made further extensive study, and a result, they found a compound having an A₂ receptor antagonism, particularly a compound having an A_{2b} receptor antagonism, exhibits a gentle but strong defecation-promoting action without causing diarrhea, and the present invention was thereby completed.

[0009] That is, the present invention relates to (14) a compound represented by the formula:



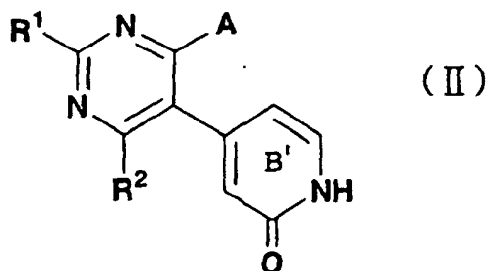
(wherein A represents a phenyl group, pyridyl group, thienyl group or furyl group which may be substituted with one or two groups selected from a halogen atom, a hydroxyl group, a C₁₋₆ alkyl group, a C₁₋₆ alkoxy group and a C₁₋₆ alkoxy-carbonyl group;

B represents a pyridyl group which may be substituted with one or more groups selected from a halogen atom, a hydroxyl group, a C₁₋₆ alkyl group and an amino group;

R¹ represents a hydrogen atom, a morpholinyl group or a group represented by the formula -NR^{1a}R^{1b} (wherein R^{1a} and R^{1b} are the same as or different from each other and each represents a hydrogen atom, a C₁₋₆ alkyl group, a C₁₋₆ acyl group, a phenyl group or a C₁₋₆ alkylsulfonyl group); and

R² represents a hydrogen atom or a group represented by the formula -NR^{2a}R^{2b} (wherein R^{2a} and R^{2b} are the same as or different from each other and each represents a hydrogen atom or a C₁₋₆ alkyl group),

provided that, in the above definition, the cases where (i) A is a 4-fluorophenyl group; B is a 4-pyridyl group; R¹ is an amino group; and R² is a hydrogen atom, and (ii) A is a 4-fluorophenyl group; B is a 4-pyridyl group; R¹ is an acetamide group; and R² is a hydrogen atom are excluded) or a salt thereof, (15) a compound represented by the formula:



(wherein A, R¹ and R² have the same meanings as defined in the above-mentioned (16); and B' is a 1,2-dihydro-2-pyridinone-4-yl group which may be substituted with one or more groups selected from a halogen atom, a hydroxyl group, a C₁₋₆ alkyl group and an amino group) or a salt thereof, (16) a pharmaceutical composition comprising the compound described in the above-mentioned (14) or (15), or a salt of them, (17) the composition according to the above-mentioned (16), which is an adenosine A_{2b} receptor antagonist, (18) the composition according to the above-mentioned (16), which is a defecation-promoting agent, (19) the composition according to the above-mentioned (16), which is an agent for treating, preventing or improving constipation, (20) the composition according to the above-mentioned (16), which is an agent for treating, preventing or improving functional constipation, (21) the composition according to the above-mentioned (20), wherein the functional constipation is spastic constipation or atonic constipation, (22) The composition according to the above-mentioned (16), which is an agent for treating, preventing or improving irritable bowel syndrome or constipation accompanying irritable bowel syndrome, (23) the composition accord-

ing to the above-mentioned (16), which is an agent for treating, preventing or improving organic constipation, constipation accompanying enteroparalytic ileus, constipation accompanying congenital digestive tract dysfunction or constipation accompanying ileus, and (24) the composition according to the above-mentioned (16), which is for evacuating intestinal tracts at the time of examination of digestive tracts or before and after an operation.

[0010] The present invention relates to use of a compound represented by the formula (I) or (II) or a salt of them for producing a pharmaceutical composition for promoting defecation, and to use of a compound represented by the formula (I) or (II) or a salt of them for producing a pharmaceutical composition for treating, preventing or improving constipation.

[0011] Hereinafter, the meanings of symbols, terms, etc. used in the present specification are described, and the present invention is described in detail.

[0012] In this specification, the "defecation-promoting agent" refers to a pharmaceutical composition promoting physiological defecation.

[0013] In this specification, the "constipation" refers to conditions where defecation is felt to be difficult or is rare, and includes various kinds of constipation such as functional constipation, organic constipation, enteroparalytic ileus, IBS, constipation accompanying IBS, constipation accompanying congenital digestive tract dysfunction and constipation accompanying ileus. Further the "constipation" also includes conditions with some sufferings and difficulties even in a small amount of defecation. Herein, the functional constipation refers to acute constipation and various kinds of chronic constipation (for example, atonic constipation, spastic constipation, dyschezia, rectal constipation, chemically inducible constipation etc.).

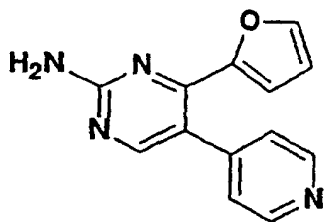
[0014] In this specification, the "compound" refers to both non-peptide compound and peptide compound. The "compound" may form a salt, or may form either an anhydride or a hydrate.

[0015] In this specification, the "salt" is not particularly limited insofar as it is a pharmacologically acceptable salt of the compound having an A_2 receptor antagonism or the compound having an A_{2b} receptor antagonism, and preferable examples thereof include 1) hydrohalogenic acid salts (for example, hydrofluoride, hydrochloride, hydrobromide and hydroiodide); 2) inorganic acid salts (for example, sulfate, nitrate, perchlorate, phosphate, carbonate and bicarbonate); 3) organic carboxylic acid salts (for example, acetate, oxalate, maleate, tartrate and fumarate); 4) organic sulfonic acid salts (for example, methanesulfonate, trifluoromethanesulfonate, ethanesulfonate, benzenesulfonate, toluenesulfonate and camphor sulfonate); 5) amino acid salts (for example, aspartate and glutamate); 6) quaternary amine salts; 7) alkali metal salts (for example, sodium salt and potassium salt); and 8) alkaline earth metal salts (for example, magnesium salt and calcium salt).

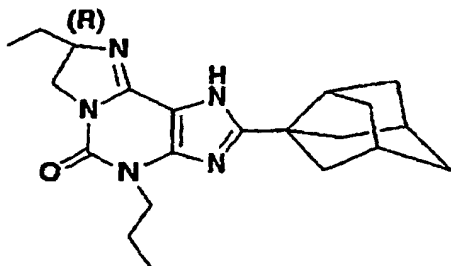
[0016] In this specification, the "antagonism" refers to the action of inactivating by blocking the interaction of the adenosine receptor with its ligand (adenosine), that is, by blocking the binding of the ligand to the receptor. The "compound having an antagonism" refers to a compound having the action of inactivating by blocking the binding of the ligand (adenosine) to the adenosine receptor.

[0017] Hereinafter, Test Examples are described to demonstrate that the pharmaceutical composition according to the present invention is useful as a pharmaceutical composition (referred to hereinafter as "defecation-promoting agent") promoting defecation (Test Examples 1 to 3). The compounds used in the test are compounds represented by the formulae:

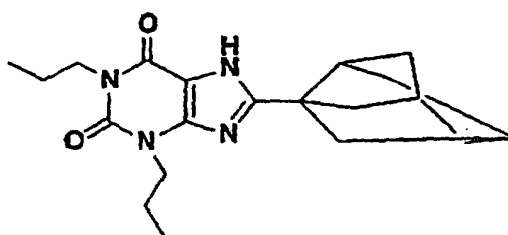
Compound I: 2-Amino-4-(2-furyl)-5-(4-pyridyl)pyrimidine



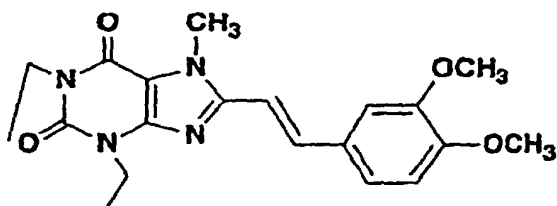
KF20274*



KW3902*



KW6002*



* These compounds are outside the scope of the present invention.

Compound I is a novel A_{2b} receptor antagonist (Example No. 3) found by the present inventors. On one hand, KF20274 and KW3902 are known as selective A_1 receptor antagonists, while KW6002 is known as a selective A_{2a} receptor antagonist. The ability of these compounds to bind to adenosine receptor subtype and the inhibitory ability thereof are shown below (Table 6). KF20274 was produced by a process described in J. Med. Chem., Vol. 35, No. 19, 3578-3581 (1992), KW3902 by a process in J. Med. Chem., Vol. 35, No. 5, 924-930 (1992), and KW6002 by a process in Bioorg. & Med. Chem. Lett., Vol. 7, No. 18, 2349-2352 (1997).

Test Example 1 Inhibitory effect of adenosine A_{2b} receptor antagonist on suppressing action of NECA on Carbachol-stimulated contraction of colon

(1) Excision of the colon

[0018] The abdomen of a rat under anesthesia with ether was opened, and from the rectum to the cecum was excised therefrom and soaked in ice-cooled Tyrode solution (containing 136 mM NaCl, 2.7 mM KCl, 0.4 mM $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$, 5.6 mM glucose, 11.9 mM NaHCO_3 , 1 mM $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$, 1.8 mM CaCl_2). Surrounding connective tissues were removed, and the intestinal tract was cut at positions apart by 1.5 cm from the rectum and by 3 cm from the cecum, to give a colon tract of about 3 cm in full length. Both the terminals of the colon tract were pinched respectively with Serrefines (trade name) to which a string had been connected, and the colon tract with the side of the cecum facing upward was immediately suspended in a Magnus tube filled with Tyrode solution previously warmed at 37°C , and then equilibrated by bubbling with a gas ($\text{O}_2/\text{CO}_2=95/5$). The string connected to the Serrefines (trade name) at the side of the cecum was suspended, and the change in the length of the colon tract was detected with an amplifier for strain pressure (Nihon Kohden Corporation).

(2) Contraction of the colon tract with Carbachol

[0019] Carbachol (Sigma) at each concentration diluted 100-fold was added accumulatively in a volume of 1/100 to the Magnus tube, and the change in the length of the colon tract was measured, and the length thereof in the absence of Carbachol was regarded as 0 % contraction, and the length thereof in the presence of 1.44 μM Carbachol was regarded as 100 % contraction. In the experiment, 3 samples were used.

(3) Inhibitory effect of NECA on Carbachol-stimulated contraction of the colon tract

[0020] To the colon tract in the presence of 1.44 M Carbachol in the Magnus tube was added accumulatively a volume of 1/100 of NECA (Sigma) diluted 100-fold, and the change in the length of the colon tract was measured. Assuming that the length thereof in the absence of Carbachol was regarded as 0 % contraction while the length thereof in the presence of 1.44 μM Carbachol was regarded as 100 % contraction, the contraction thereof in the presence of NECA was determined. In the experiment, 3 samples were used.

(4) Inhibitory effect of adenosine receptor antagonist on suppressing action of NECA on Carbachol-stimulated contraction of the colon tract

[0021] 0.3 μM Carbachol and 1 μM NECA were successively added to the colon tract, and Compound I, KF20274 or KW6002 diluted 100-fold was accumulatively added in a volume of 1/100 to the Magnus tube, and the change in the length of the colon tract was measured. Assuming that the length thereof in the presence of 0.3 μM Carbachol and 1 μM NECA was regarded as 0 % contraction while the length thereof in the presence of 0.3 M Carbachol only was regarded as 100 % contraction, the contraction in the presence of each of the adenosine receptor antagonists was determined. In the experiment, 3 samples were used.

[0022] By stimulation with Carbachol (the above operation 2), the colon tract showed contraction in a manner dependent on the concentration of Carbachol (Table 1). When the adenosine receptor agonist NECA was added thereto (the above operation 3), its inhibitory effect on the contraction was observed in a manner depending on the concentration of NECA (Table 2). Carbachol has nicotinic and muscarinic acetylcholine receptor-stimulating actions in autonomic ganglions and smooth muscles respectively, so the inhibitory effect of NECA on the contraction could not be elucidated only by its action working via nerves distributed in smooth muscles, thus suggesting the possibility of its direct action on smooth muscles. Further, when each antagonist for adenosine receptor was added to this system (the above operation 4), Compound I inhibited the suppressing effect of NECA on the contraction, in a manner depending on the concentration of Compound I (Table 3). On one hand, the A_1 -selective antagonist KF20724 and A_{2a} -selective antagonist KW6002 did not show any inhibitory effect. This indicates that the contraction-suppressing effect of NECA is not an action mediated via A_1 and A_{2a} receptors, thus suggesting the involvement of A_{2b} receptor. It was thus suggested that adenosine could suppress contraction of the colon directly via the A_{2b} receptor in colon smooth muscles, and the present inventors succeeded in directly demonstrating that the A_{2b} receptor antagonist could antagonize to promote contraction of the colon.

Table 1

Carbachol (μM)	Contraction (%)	
	Mean	Standard Error
0.01	1.4	1.4
0.04	24.5	10.4
0.14	69.1	5.5
0.44	87.0	2.4
1.44	100.0	0.0

Table 2

NECA(μM)	Contraction (%)	
	Mean	Standard Error
0.1	89.0	3.2
0.4	75.3	4.9

Table 2 (continued)

NECA(μ M)	Contraction (%)	
	Mean	Standard Error
1.4	63.1	6.8
4.4	59.2	4.6
14.4	54.9	8.9
Carbachol 1.44 μ M (singly added) = 100%		

Table 3

Compound I (μ M)	Contraction (%)	
	Mean	Standard Error
0.1	71.5	36.2
0.4	111.0	51.9
1.4	122.0	53.1
4.4	85.9	35.6
KW20274 (μ M)		
	Mean	Standard Error
0.1	-8.2	4.8
0.4	-26.0	20.7
1.4	-40.0	24.2
4.4	-71.0	35.7
KW6002 (μ m)		
	Mean	Standard Error
0.1	5.2	3.4
0.4	1.1	4.2
1.4	-2.9	3.3
4.4	-3.9	7.8
Carbachol 0.3 μ M + NECA 1 μ M = 0%		
Carbachol 0.3 μ M (singly added) = 100%		

Test Example 2 Defecation-promoting action of the adenosine A_{2b} receptor antagonist in rat

[0023] The present inventors examined and compared the action of the A_{2b} receptor antagonist (Compound I), the A_1 -selective antagonist or the A_{2a} -selective antagonist on defecation in rats.

[0024] SD IGS rats (6-weeks-old, from Charles River) were placed in cages (3 animals/cage) and preliminarily allowed food and water ad libitum and raised for 1 week. On the day of the experiment, their weight was measured, a water-absorbing sheet was placed below each cage, and the animals were fasted but allowed water ad libitum throughout the experiment. Three hours after fasting was initiated, the fecal pellets were recovered from each cage and observed for abnormality before the experiment, and then the compound suspended or dissolved in 0.5 % (W/V) methyl cellulose (MC) was orally administered into each rat in a dose of 5 ml/kg. On one hand, 0.5 % (W/V) MC only was orally given to the control group. After administering the compound, the rats were returned to the cage provided with a new water-absorbing sheet of known weight, and 180 minutes after the administration, the fecal pellets on the water-absorbing sheet were recovered from each cage, and the external appearance was observed, and the number of fecal pellets was counted. The number of fecal pellets is expressed per each cage (Table 4). After the fecal pellets were recovered, the water-absorbing sheet was weighed, and the weight determined by subtracting the initial weight of the water-adsorbing sheet from the weight after the experiment was regarded as the volume of urine and expressed as the volume of urine per 100 g of the body weight (Table 4).

Table 4

Compound	Dose	The number of fecal pellets/3 rats	Urine Volume (g/100g body weight)
Control	-	1.00±0.68	0.89±0.10
Compound 1	3 mg/kg	16.33±1.82	0.79±0.09
	10 mg/kg	30.00±2.79	1.23±0.13
KW3902	0.3 mg/kg	10.67±2.08	2.08±0.04
	1 mg/kg	14.50±1.18	2.15±0.09
	3 mg/kg	12.83±1.66	2.01 ±0.06
KW6002	1 mg/kg	6.67±1.63	0.72±0.07
	3 mg/kg	7.00±0.86	0.76±0.05

[0025] As shown in Table 4, the A₁-selective receptor antagonist KW3902 exhibits a defecation-promoting action, but this action can be seen to reach the maximum in a dose of 1 mg/kg. Further, the A_{2a}-selective receptor antagonist KW6002 had a low defecation-promoting action. On one hand, the A_{2b} receptor antagonist Compound I did not cause diarrhea and showed an evidently higher defecation-promoting action than the A₁-selective antagonist KW3902 or the A_{2a}-selective antagonist KW6002. Compound I is a compound also having an antagonistic, inhibitory action on A₁ receptor, but this strong defecation-promoting action cannot be elucidated in terms of the absorption or different dose of the compound having an antagonistic, inhibitory action on A₁ receptor. This is because compounds having an antagonistic, inhibitory action on A₁ receptor are well known to have a diuretic action (J. Pharmacol. Exp. Ther., 266, 200 (1993)), but the A₁-selective antagonist KW3902 has a stronger diuretic action than Compound I, while its defecation-promoting action is weaker than Compound I. On the other hand, Compound I has a weaker diuretic action than the A₁-selective antagonist KW3902, whereas its defecation-promoting action is stronger.

[0026] That is, Table 4 shows that the action of Compound I cannot be elucidated only by the antagonistic action on A₁ receptor, and that the stronger defecating action was brought about by adding the antagonistic, inhibitory action on A_{2b} receptor.

Test Example 3 Contribution of inhibition of adenosine A_{2b} receptor to defecation-promoting action

[0027] For the purpose of further examination of contribution of the antagonistic inhibitory action of Compound I on A_{2b} receptor to the strong defecation-promoting action thereof, a combination of the A₁-selective antagonist KW3902 and the A_{2a}-selective antagonist KW6002 was administered and compared with Compound I. Test rats and the compounds were raised and prepared in the same manner as in Test 1. After administering the compounds, the rats were returned to the cage under which a new water-absorbing sheet had been installed, and after 180 minutes, the fecal pellets on the water-absorbing sheet were recovered from each cage, and the outward appearance was observed and the number of fecal pellets was counted. The number of fecal pellets is expressed per cage (Table 5).

Table 5

Compound	Dose	KW6002 (1 mg/kg)	The number of fecal pellets/3 rats
Control	-	-	2.50±0.65
Compound 1	3 mg/kg	-	34.00±1.00
KW3902	0 mg/kg	+	7.00±1.58
	1 mg/kg	-	9.00±1.08
	1 mg/kg	+	18.25±1.49

[0028] In Test Example 3, the A₁-selective antagonist KW3902 was administered in a dose enough to exhibit a diuretic action. As shown in Table 5, when the A₁-selective antagonist KW3902 and the A_{2a}-selective antagonist KW6002 were simultaneously administered, both their respective defecation-promoting actions were brought about. Accordingly, a compound having both an antagonistic action on A₁ receptor and an antagonistic action on A_{2a} receptor is considered to exhibit a stronger defecation-promoting action than by a single A₁-selective antagonist. However, their action did not reach the defecation-promoting action of Compound I as the A_{2b} receptor antagonist. That is, the result in Table 5

shows that the contribution of A_{2b} receptor antagonism is very important for promotion of defecation.

Comprehensive Discussion

[0029] The test revealed that the compound antagonistically inhibiting A_{2b} receptor exhibits a strong defecation-promoting action without causing diarrhea, and its action is further stronger than that of the A₁-selective antagonist. Accordingly, a pharmaceutical preparation comprising the compound having an A_{2b} receptor antagonism or a salt thereof is useful as a defecation-promoting agent, and in particular a pharmaceutical preparation comprising the A_{2b} receptor antagonist is very useful. It is therefore evident that the defecation-promoting agent of the invention is useful as an agent for treating, preventing or improving various kinds of constipation, and can exhibit an excellent effect as an agent for treating, preventing or improving for example functional constipation (acute constipation and various kinds of chronic constipation (for example, atonic constipation, spastic constipation, dyschezia, rectal constipation, chemically inducible constipation etc.)), organic constipation, enteroparalytic ileus, IBS, constipation accompanying IBS, constipation accompanying congenital digestive tract dysfunction, constipation accompanying ileus etc. Further, use of the defecation-promoting agent of the invention as a pharmaceutical preparation is very useful not only for treating, preventing or improving various kinds of constipation, but also as a chemical for evacuating intestinal tracts at the time of examination of digestive tracts or before and after an operation, as an aid for defecation after an operation, and as a chemical for promoting defecation after administering a contrast medium.

Measurement of the ability of the compound to bind to and inhibit the receptors

[0030] The ability of the compound to bind to and the ability thereof to inhibit each subtype of adenosine receptor was measured in a known method described below.

1) Measurement of the ability to bind to adenosine A₁ receptor

[0031] A human adenosine A₁ receptor cDNA was expressed in excess in CHOK1 cells, and this membrane sample was added at a protein concentration of 66.7 µg/ml to, and suspended in, 20 mM HEPES buffer, pH 7.4 (10 mM MgCl₂, 100 mM NaCl). To 0.45 ml of this membrane sample suspension were added 0.025 ml of 60 nM tritium-labeled chlorocyclopentyl adenosine (³H-CCPA, from NEN Ltd.) and 0.025 ml test compound. This mixture was left at 30°C for 120 minutes, filtered rapidly under suction through a glass fiber filter (GF/B, from Whatman), and immediately washed twice with 5 ml of 50 mM water-cooled Tris-HCl buffer. Thereafter, the glass fiber filter was transferred to a vial, a scintillator was added thereto, and the radioactivity on the filter was measured by a liquid scintillation counter. The inhibition of binding of ³H-CCPA to A₁ receptor by the test compound was determined using the following formula, and from this inhibition, 50 % inhibition concentration (IC₅₀) was calculated (the following equation).

$$\text{Inhibition (\%)} = [1 - \{ \text{binding in the presence of the test compound} - \text{non-specific binding} \} / (\text{total binding} - \text{non-specific binding})] \times 100$$

[0032] In the above formula, the total binding means ³H-CCPA-bound radioactivity in the absence of the test compound; the non-specific binding means ³H-CCPA-bound radioactivity in the presence of 100 µM RPIA ([R]-[1-methyl-2-phenylethyl] adenosine); and the binding in the presence of the test compound means ³H-CCPA-bound radioactivity in the absence of the test compound at predetermined concentrations. The inhibition constant (K_i value) in the table was determined from the formula of Cheng-Prusoff.

2) Measurement of the ability to bind to adenosine A_{2a} receptor

[0033] An experiment of inhibition of binding to adenosine A_{2a} receptor was conducted using a membrane sample (Receptor Biology Inc.) where an adenosine A_{2a} receptor cDNA was expressed in excess. This membrane sample was added at a protein concentration of 22.2 µg/ml to, and suspended in, 20 mM HEPES buffer, pH 7.4 (10 mM MgCl₂ and 100 mM NaCl). To 0.45 ml of this membrane sample suspension were added 0.025 ml of 500 nM tritium-labeled 2-p-[2-carboxyethyl]phenethylamino-5'-N-ethylarboxamide adenosine (³H-CGS21680, from NEN) and 0.025 ml test compound. This mixture was left at 25°C for 90 minutes, filtered rapidly under suction through a glass fiber filter (GF/B, from Whatman), and immediately washed twice with 5 ml of 50 mM water-cooled Tris-HCl buffer. Thereafter, the

glass fiber filter was transferred to a vial, a scintillator was added thereto, and the radioactivity on the filter was measured by a liquid scintillation counter. The inhibition of binding of ^3H -CGS21680 to A_{2a} receptor by the test compound was determined using the following formula, and from this inhibition, 50 % inhibition concentration (IC_{50}) was calculated.

$$\text{Inhibition (\%)} = \left[1 - \frac{\text{binding in the presence of the test compound} - \text{nonspecific binding}}{\text{total binding} - \text{nonspecific binding}} \right] \times 100$$

[0034] In the above formula, the total binding means ^3H -CGS21680-bound radioactivity in the absence of the test compound; the nonspecific binding means ^3H -CGS21680-bound radioactivity in the presence of 100 μM RPIA; and the binding in the presence of the test compound means ^3H -CGS21680-bound radioactivity in the absence of the test compound at predetermined concentrations. The inhibition constant (K_i value) in the table was determined from the formula of Cheng-Prusoff.

3) Experiment of inhibition of NECA-stimulated production of cAMP in adenosine A_{2b} receptor-expressing cells

[0035] CHOK1 cells where a human adenosine A_{2b} receptor had been expressed in excess were plated onto a 24-well plate at a density of 1.5×10^5 cells/well, cultured overnight, and used in the experiment. The degree of inhibitory effect of the test compound on the amount of cAMP produced by stimulation with 30 nM 5'-N-ethylcarboxamide adenosine (NECA from Sigma) was evaluated in terms of affinity for A_{2b} receptor. That is, the adhering cells were washed twice with 2 ml/well Krebs-Ringer buffer solution (containing 0.1% BSA; pH 7.4) and pre-incubated for 30 minutes in a volume of 0.5 ml/well. Then, a mixed solution containing NECA and the test compound was added in a volume of 0.1 ml/well in the presence of a phosphodiesterase inhibitor Ro-20-1724 (a product of RBI). After pre-incubation for 15 minutes, the reaction was terminated with 0.1 N HCl in a volume of 300 μl /well. Measurement of intracellular cAMP was carried out using a cAMP enzyme immunoassay kit produced by Amersham. The inhibition of NECA-stimulated production of cAMP by the test compound was determined using the following equation:

$$\text{Inhibition (\%)} = \left[1 - \frac{\text{amount of cAMP in the coexistence of NECA and the test compound} - \text{amount of cAMP in only the Krebs-Ringer buffer solution}}{\text{amount of cAMP upon stimulation with NECA only} - \text{amount of cAMP in only the Krebs-Ringer buffer solution}} \right] \times 100$$

[0036] From the inhibition thus determined, 50 % inhibition concentration (IC_{50}) was determined.

[0037] The results of the experiment of measuring the ability to bind to, and the ability to inhibit, each receptor are as follows (Table 6).

Table 6

Test Compound	A_1 receptor K_i (nM)	A_{2a} receptor K_i (nM)	A_{2b} receptor IC_{50} (nM)
Compound I	660	112	8.4
KW3902	10	40	126
KW6002	22600	52	2850

[0038] For example, the defecation-promoting actions of 8-phenyltheophylline ("8 - PT" in the table below) and 5-[6-amino-8-(3-fluorophenyl)-9H-9-purinyl]-1-methyl-1,2-dihydro-2-pyridinone (Compound II in the table below) disclosed in Example Number 5 described in WO 2001/2400 were as shown below. 8-PT can be easily produced according to the description of Drug Development Research 47: 45-53 (1999), or is easily available as a commercial product (in this test, it was purchased from Sigma).

Table 8

Compound	Dose	The number of fecal pellets/3 rats	
Control	-	3.25±2.02	
8-PT	3 mg/kg	8.75±1.75	NS
	10 mg/kg	13.75±0.85	**
Compound I	3 mg/kg	20.75±3.15	***

The number of cages; n=4 cages/group (12 rats/group)

p<0.01, *p<0.001, NS; not significant, Dunnett's test

Compound	Dose	The number of fecal pellets/3 rats	
Control	-	2.5±0.87	
Compound II	1 mg/kg	12.5±1.44	**
	3 mg/kg	18.5±1.94	***
	10 mg/kg	20.75±1.70	***
Compound I	3 mg/kg	19.75±2.50	***

The number of cages; n=4 cages/group (12 rats/group)

p<0.01, *p<0.001, Dunnett's test

[0039] The present invention relates to a compound represented by the above formula (I) or (II) or a salt of them. The compound is a novel pyrimidine compound found in the process of searching for the defecation-promoting pharmaceutical composition according to the present invention. The compound is a compound exhibiting an excellent antagonistic action on adenosine A₂ receptor, particularly on adenosine A_{2b} receptor and having an excellent defecation-promoting action.

[0040] The structural formulae of the compounds represented by the formula (I) or (II) in the present invention or a salt thereof may, for convenience' sake, indicate a certain isomer, but this invention encompasses all possible isomers which can occur in the structures of the compounds, for example geometric isomer, optical isomer based on asymmetrical carbon, stereoisomer and tautomer, as well as a mixture of such isomers, so the compound of the invention may be any isomers or a mixture thereof without limitation to the formulae shown for convenience sake. Compound (I) or (II) can have an intramolecular asymmetrical carbon to occur as optically active isomers or racemic modifications, and any of such compounds are included in this invention without limitation. When there is crystal polymorphism, the compound of the invention may be in a single crystal form or a mixed crystal form without limitation. Compound (I) or (II) in the invention or salts thereof may be anhydrides or hydrates, any of which fall under the claims in this specification. Further, metabolites formed by decomposition of Compound (I) or (II) in the living body, as well as prodrugs of Compound (I) or (II) or salts thereof, also fall under the claims in this specification.

[0041] The "halogen atom" used in this specification refers to an atom such as, for example, a fluorine atom, a chlorine atom, a bromine atom or an iodine atom, preferably a fluorine atom, a chlorine atom or a bromine atom, more preferably a fluorine atom or a chlorine atom, still more preferably a fluorine atom.

[0042] The "C₁₋₆ alkyl group" used in this specification refers to an alkyl group containing 1 to 6 carbon groups, and examples thereof include linear or branched alkyl groups, preferably a methyl group, ethyl group, n-propyl group, iso-propyl group, n-butyl group, iso-butyl group, sec-butyl group, tert-butyl group, n-pentyl group, 1,1-dimethylpropyl group, 1,2-dimethylpropyl group, 2,2-dimethylpropyl group, 1-ethylpropyl group, 2-ethylpropyl group, n-hexyl group, 1-methyl-2-ethylpropyl group, 1-ethyl-2-methylpropyl group, 1,1,2-trimethylpropyl group, 1-propylpropyl group, 1-methylbutyl group, 2-methylbutyl group, 1,1,-dimethylbutyl group, 1,2-dimethylbutyl group, 2,2-dimethylbutyl group, 1,3-dimethylbutyl group, 2,3-dimethylbutyl group, 2-ethylbutyl group, 2-methylpentyl group, 3-methylpentyl group etc., more pref-

erably a methyl group, ethyl group, n-propyl group, iso-propyl group, n-butyl group, iso-butyl group, sec-butyl group, tert-butyl group, n-pentyl group etc.

[0043] The "C₁₋₆ alkoxy group" used in this specification refers to an alkoxy group containing 1 to 6 carbon groups, and preferable examples include e.g. a methoxy group, ethoxy group, n-propoxy group, iso-propoxy group, sec-propoxy group, n-butoxy group, iso-butoxy group, sec-butoxy group, tert-butoxy group, n-pentyloxy group, iso-pentyloxy group, sec-pentyloxy group, n-hexoxy group, iso-hexoxy group, 1,1-dimethylpropyloxy group, 1,2-dimethylpropyloxy group, 2,2-dimethylpropyloxy group, 2-ethylpropoxy group, 1-methyl-2-ethylpropoxy group, 1-ethyl-2-methylpropoxy group, 1,1,2-trimethylpropoxy group, 1,1,2-trimethyl propoxy group, 1,1-dimethylbutoxy group, 1,2-dimethylbutoxy group, 2,2-dimethylbutoxy group, 2,3-dimethylbutyloxy group, 1,3-dimethylbutyloxy group, 2-ethylbutoxy group, 1,3-dimethylbutoxy group, 2-methylpentoxy group, 3-methylpentoxy group, hexyloxy group etc.

[0044] The "C₁₋₆ alkoxy-carbonyl group" used in this specification refers to a carbonyl group to which a C₁₋₆ alkoxy group was bound, and examples thereof include a methoxycarbonyl group, ethoxycarbonyl group, n-propoxycarbonyl group, isopropoxycarbonyl group, sec-propoxycarbonyl group, n-butoxycarbonyl group, iso-butoxycarbonyl group, sec-butoxycarbonyl group, tert-butoxycarbonyl group, n-pentyloxycarbonyl group, iso-pentyloxycarbonyl group, sec-pentyloxycarbonyl group, n-hexoxycarbonyl group, isohexoxycarbonyl group, 1,1-dimethylpropyloxycarbonyl group, 1,2-dimethylpropyloxycarbonyl group, 2,2-dimethylpropyloxycarbonyl group, 2-ethylpropyloxycarbonyl group, 1-methyl-2-ethylpropyloxycarbonyl group, 1-ethyl-2-methylpropyloxycarbonyl group, 1,1,2-trimethylpropyloxycarbonyl group, 1,1,2-trimethylpropyloxycarbonyl group, 1,1-dimethylbutoxycarbonyl group, 1,2-dimethylbutoxycarbonyl group, 2,2-dimethylbutoxycarbonyl group, 2,3-dimethylbutyloxycarbonyl group, 1,3-dimethylbutyloxycarbonyl group, 2-ethylbutoxycarbonyl group, 1,3-dimethylbutoxycarbonyl group, 2-methylpentoxy carbonyl group, 3-methylpentoxy carbonyl group, hexyloxycarbonyl group etc.

[0045] The "acyl group" used in this specification refers to an atomic group derived from a C₁₋₇ fatty acid carboxyl group by removing its OH group, and preferable groups include e.g. an acetyl group, propionyl group, butyryl group etc.

[0046] The "C₁₋₆ alkyl sulfonyl group" used in this specification refers to a sulfonyl group to which a C₁₋₆ alkyl group was bound, and preferable groups include a methylsulfonyl group, ethylsulfonyl group, n-propylsulfonyl group, isopropylsulfonyl group, n-butylsulfonyl group, isobutylsulfonyl group, sec-butylsulfonyl group, tert-butylsulfonyl group, n-pentylsulfonyl group, n-hexylsulfonyl group etc.

[0047] In the formula (I) or (II), A represents a phenyl group; a pyridyl group, a thienyl group or a furyl group which may be substituted with one or two groups selected from a halogen atom, a hydroxyl group, a C₁₋₆ alkyl group, a C₁₋₆ alkoxy group and a C₁₋₆ alkoxy-carbonyl group, and preferable examples of the group A are not particularly limited. More preferable examples of the group A include a phenyl group, a pyridyl group, a thienyl group and a furyl group, each of which may be substituted with one to three groups selected from a fluorine atom, a chlorine atom, a hydroxyl group, a methyl group, an ethyl group, a methoxy group and an ethoxy group. Still more preferable groups include 1) a phenyl group, 2-pyridyl group, 3-pyridyl group, 4-pyridyl group, 2-furyl group, 3-furyl group, 2-thienyl group and 3-thienyl group, each of which is unsubstituted, and 2) a phenyl group, 2-pyridyl group, 3-pyridyl group, 4-pyridyl group, 2-furyl group, 3-furyl group, 2-thienyl group, 3-thienyl group etc., each of which is substituted with one to three groups selected from a fluorine atom, chlorine atom, hydroxyl group, methyl group, ethyl group, methoxy group and ethoxy group.

[0048] In the formula (I), B represents a pyridyl group which may be substituted with one or more groups selected from a halogen atom, a hydroxyl group, a C₁₋₆ alkyl group and an amino group, and preferable examples of the group B are not particularly limited. More preferable examples of the group B is 1) an unsubstituted 4-pyridyl group or 2) a 4-pyridyl group which is substituted with one to three groups selected from a fluorine atom, a chlorine atom, a hydroxyl group, a methyl group, an ethyl group, a n-propyl group, an iso-propyl group and an amino group.

[0049] In the formula (II), B' represents a 1,2-dihydro-2-pyridinone-4-yl group which may be substituted with one or more groups selected from a halogen atom, a hydroxyl group, a C₁₋₆ alkyl group and an amino group, and preferable examples of the group B' are not particularly limited, and more preferable examples include 1) an unsubstituted 1,2-dihydro-2-pyridinone-4-yl group, 2) an 1,2-dihydro-2-pyridinone-4-yl group which is substituted with one to two groups selected from a fluorine atom, chlorine atom, hydroxyl group, methyl group, ethyl group, n-propyl group, iso-propyl group and amino group, and a still further preferable group is an unsubstituted 1,2-dihydro-2-pyridinone-4-yl group.

[0050] In the above formula (I) or (II), R¹ represents a hydrogen atom, a morpholinyl group, or a group represented by the formula -NR^{1a}R^{1b} (wherein R^{1a} and R^{1b} are the same as or different from each other and each represents a hydrogen atom, a C₁₋₆ alkyl group, a C₁₋₆ acyl group, a phenyl group or a C₁₋₆ alkyl sulfonyl group), and 1) a hydrogen atom, 2) a 4-morpholinyl group, 3) an amino group, 4) a C₁₋₆ alkylamino group (for example, a methylamino group, ethylamino group, n-propylamino group, iso-propylamino group etc.), 5) an N,N-diC₁₋₆ alkyl amino group (for example, a dimethylamino group, diethylamino group, etc.), 6) a C₁₋₆ acyl amino group (for example, an acetamide group, propionylamino group, etc.), 7) an N,N-C₁₋₆ alkyl (C₁₋₆ acyl) amino group and 8) a C₁₋₆ alkylsulfonylamino group (for example, a methylsulfonylamino group, an ethylsulfonylamino group, a n-propylsulfonylamino group, an iso-propylsulfonylamino group, etc.) are more preferable.

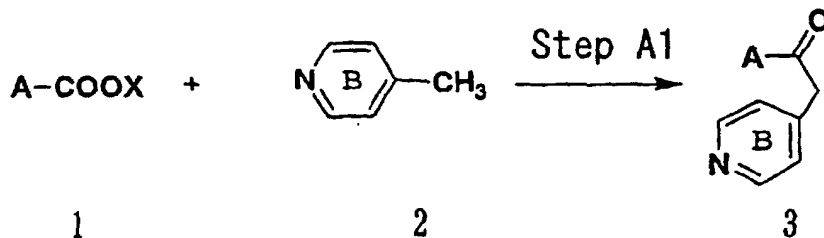
[0051] In the formula (I) or (II), R² represents a hydrogen atom or a group represented by the formula -NR^{2a}R^{2b} (wherein R^{2a} and R^{2b} are the same as or different from each other and each represents a hydrogen atom or a C₁₋₆ alkyl group, and more preferable groups include a hydrogen atom, an amino group, a methyl amino group, an ethyl amino group, an N,N-dimethylamino group, an N,N-methylethylamino group, etc.

[0052] Preferable examples of Compound (I) or (II) include the following compounds:

6-(3-fluorophenyl)-5-(4-pyridyl)-2,4-pyrimidinediamine; 6-(2-furyl)-5-(4-pyridyl)-2,4-pyrimidinediamine; 4-(2-furyl)-5-(4-pyridyl)-2-pyrimidinylamine; 4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinylamine; 4-phenyl-5-(4-pyridyl)-2-pyrimidinylamine; 5-(4-pyridyl)-4-(2-thienyl)-2-pyrimidinylamine; 4-(2-pyridyl)-5-(4-pyridyl)-2-pyrimidinylamine; 4-(3-fluorophenyl)-5-(4-pyridyl)pyrimidine; 4-(3-fluorophenyl)-5-(2-fluoro-4-pyridyl)pyrimidine; 4-(3-fluorophenyl)-5-(2-fluoro-4-pyridyl)-2-pyrimidinylamine; N-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]-N,N-dimethylamine; N-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]-N-methylamine; 4-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]morpholine; N-[4-(3-fluorophenyl)-5-(2-fluoro-4-pyridyl)-2-pyrimidinyl]-N-methylamine; 4-[4-(3-fluorophenyl)-2-(methylamino)-5-pyrimidinyl]-1,2-dihydro-2-pyridinone; N-ethyl-N-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]amine; N1-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]acetamide; N1-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]-N1-methylacetamide; N1-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]propanamide; N1-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]butanamide; N1-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]-N1-methylpropanamide; 4-(3-fluorophenyl)-5-(2-methyl-4-pyridyl)-2-pyrimidinylamine; N1-ethyl-N1-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]propanamide; N1-[4-(3-fluorophenyl)-5-(2-fluoro-4-pyridyl)-2-pyrimidinyl]propanamide; N1-[4-(3-fluorophenyl)-5-(2-methyl-4-pyridyl)-2-pyrimidinyl]propanamide; 4-[2-amino-4-(3-fluorophenyl)-5-pyrimidinyl]-1,2-dihydro-2-pyridinone; N-ethyl-N-[4-(3-fluorophenyl)-5-(2-fluoro-4-pyridyl)-2-pyrimidinyl]amine; 4-[2-(ethylamino)-4-(3-fluorophenyl)-5-pyrimidinyl]-1,2-dihydro-2-pyridinone; N-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]-N-propylamine; N-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]-N-phenylamine; N-ethyl-N-[4-(3-fluorophenyl)-5-(2-methyl-4-pyridyl)-2-pyrimidinyl]amine; 5-(2,6-dimethyl-4-pyridyl)-4-(3-fluorophenyl)-2-pyrimidinylamine; N-[5-(2,6-dimethyl-4-pyridyl)-4-(3-fluorophenyl)-2-pyrimidinyl]-N-ethylamine; 4-(3-fluorophenyl)-5-(3-methyl-4-pyridyl)-2-pyrimidinylamine; 5-(3-ethyl-4-pyridyl)-4-(3-fluorophenyl)-2-pyrimidinylamine; 5-(2-amino-4-pyridyl)-4-(3-fluorophenyl)-2-pyrimidinylamine; N4-methyl-6-(3-fluorophenyl)-5-(4-pyridyl)-2,4-pyrimidinediamine; N4,N4-dimethyl-6-(3-fluorophenyl)-5-(4-pyridyl)-2,4-pyrimidinediamine; N-ethyl-N-[4-(2-furyl)-5-(4-pyridyl)-2-pyrimidinyl]amine; N-ethyl-N-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]amine; N-ethyl-N-[4-phenyl-5-(4-pyridyl)-2-pyrimidinyl]amine; N-ethyl-N-[5-(4-pyridyl)-4-(2-thienyl)-2-pyrimidinyl]amine; 5-(3-ethyl-4-pyridyl)-4-(2-furyl)-2-pyrimidinylamine; N-ethyl-N-[5-(3-ethyl-4-pyridyl)-4-(2-furyl)-2-pyrimidinyl]amine; 4-(2,5-dimethyl-3-furyl)-5-(3-ethyl-4-pyridyl)-2-pyrimidinylamine; N-[4-(2,5-dimethyl-3-furyl)-5-(3-ethyl-4-pyridyl)-2-pyrimidinyl]-N-ethylamine; 5-(2,6-dimethyl-4-pyridyl)-6-(3-fluorophenyl)-2,4-pyrimidinediamine; 4-(3-methyl-2-furyl)-5-(4-pyridyl)-2-pyrimidinylamine; N-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]methanesulfonamide; 4,5-di(4-pyridyl)-2-pyrimidinylamine; 4-(4-methoxyphenyl)-5-(4-pyridyl)-2-pyrimidinylamine; 4-(3,4-dimethoxyphenyl)-5-(4-pyridyl)-2-pyrimidinylamine; 4-[2-amino-5-(4-pyridyl)-4-pyrimidinyl]phenol; methyl 3-[2-amino-5-(4-pyridyl)-4-pyrimidinyl]benzoate; and N4,N4-dimethyl-6-(2-furyl)-5-(4-pyridyl)-2,4-pyrimidinediamine.

[0053] The compounds represented by the above formula (I) or (II) in this invention can be produced by various methods, but typical production methods are as follows. In the following production methods, "room temperature" refers usually to 10 to 35°C.

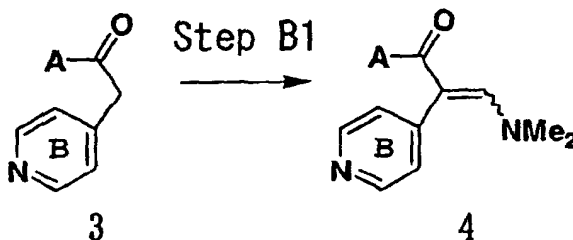
Production Method A



wherein A represents a phenyl group, pyridyl group, thienyl group or furyl group which may be substituted with one or two groups selected from a halogen atom, a hydroxyl group, a C₁₋₆ alkyl group, a C₁₋₆ alkoxy group and a C₁₋₆ alkoxy-

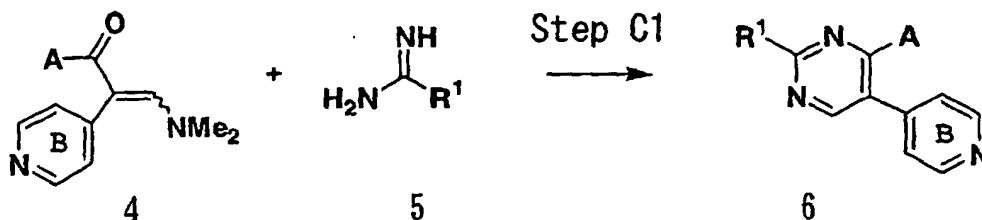
carbonyl group, B represents a pyridyl group which may be substituted with one or more groups selected from a halogen atom, a hydroxyl group, a C₁₋₆ alkyl group and an amino group, and X represents a C₁₋₈ alkyl group. Step A1 is a step of producing 1,2-biaryl-1-ethanone compound (3) which is an intermediate for production of the compound represented by the above formula (I) in this invention. That is, Compound (3) is obtained through condensation via alcohol elimination by reacting an aromatic carboxylate (1) with 4-methylpyridine derivative (2) in a solvent in the presence of a base. The base used is varied depending on the starting materials, reagents, solvent etc. used, and is not particularly limited insofar as the reaction is not inhibited, and preferable examples of the base include secondary amine metal salts such as lithium bis(trimethylsilyl)amide and lithium diisopropylamide. The solvent used is varied depending on the starting materials and reagents used, and is not particularly limited insofar as the reaction is not inhibited and the starting materials are dissolved to a certain degree, and preferable examples of the solvent include ethers such as tetrahydrofuran, dioxane, dimethoxyethane and diethylene glycol etc. The reaction temperature is preferably -78°C to room temperature, more preferably in the vicinity of 0°C.

Production Method B



wherein A and the ring B have the same meanings as defined above; and Me is a methyl group. N,N-dimethylformamide dimethyl acetal is allowed to act on the active methylene of Compound (3) produced in Production Method A, whereby 3-(dimethylamino)-2-propene-1-one compound (4) as an intermediate for production of the compound represented by the above formula (I) in this invention can be produced (step B1). This reaction is carried out preferably in the absence of a solvent, but the reaction may be carried out after diluting with a solvent not inhibiting the reaction and dissolving the starting materials to a certain degree, for example, N,N-dimethylformamide, tetrahydrofuran, dioxane, N-methyl pyrrolidone, benzene, toluene etc. However, the solvent used herein is varied depending on the starting materials, reagents etc. used, and is not particularly limited. Usually, the reaction temperature is preferably room temperature to 120°C, more preferably about 100°C.

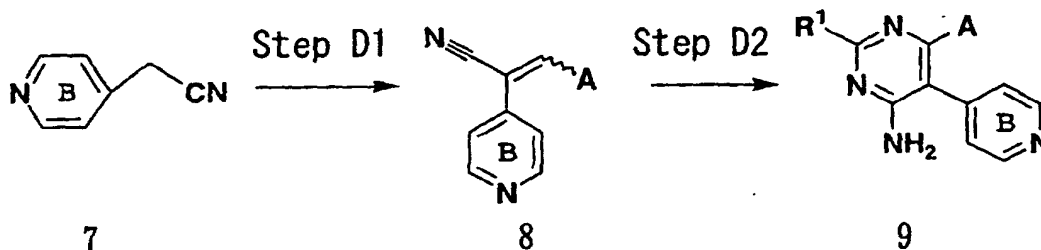
Production Method C



wherein A, B and Me have the same meanings as defined above, and R¹ represents a hydrogen atom, a morpholinyl group or a group represented by the formula -NR^{1a}R^{1b} (wherein R^{1a} and R^{1b} are the same as or different from each other and each represents a hydrogen atom, a C₁₋₆ alkyl group, a C₁₋₆ acyl group, a phenyl group or a C₁₋₆ alkylsulfonyl group). Formamidine or guanidine derivative (5) is reacted in the presence of a base with the 3-(dimethylamino)-2-propene-1-one compound (4) obtained in Production Method B, whereby Compound (6) in this invention can be produced (step C1). The guanidine derivative (5) used is not only easily commercially available but can also be produced by a known method described in e.g. J. Org. Chem., 57, 2497-2502 (1992) or its analogous method. The base used is varied depending on the starting materials, reagents, solvent etc. used, and is not particularly limited insofar as the reaction is not inhibited, and preferable examples include alkali metal carbonates (for example, potassium carbonate, sodium carbonate, etc.), alkali metal alkoxides (for example, sodium methoxide, sodium ethoxide, potassium tert-

butoxide etc.), etc. This reaction is carried out preferably in a solvent not inhibiting the reaction and dissolving the starting materials and base to a certain degree, for example in N,N-dimethylformamide, N-methylpyrrolidone, dimethylsulfoxide, methanol, ethanol etc., but it varies depending on the starting materials, reagents etc. used, and is not particularly limited. Usually, the reaction temperature is preferably room temperature to 120°C, more preferably about 70°C.

Production Method D



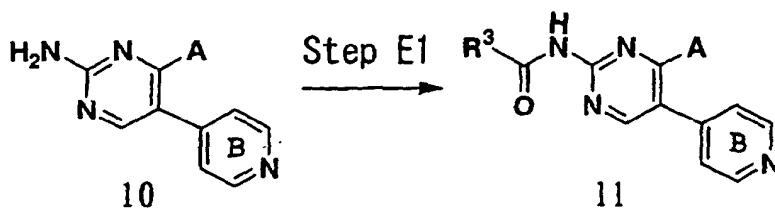
wherein A, ring B, and R¹ have the same meanings as defined above. Compound (9) in this invention can be obtained by dehydration condensation of aryl aldehyde with aryl acetonitrile (7) in the presence of a base, to produce 2,3-biaryl-2-propenenitrile (8) (step D1), then allowing formamidine or guanidine derivative to react on the nitrile compound (8) in the presence of a base and converting the product into an aromatic derivative by an oxidizing agent (step D2).

Step D1 The base used in step D1 is varied depending on the starting materials, reagents, solvent etc. used, and is not particularly limited insofar as the reaction is not inhibited, and preferable examples include alkali metal alkoxides (for example, sodium methoxide, sodium ethoxide, potassium tert-butoxide etc.), alkali metal carbonates (for example, potassium carbonate, sodium carbonate, etc.). The solvent used in the reaction is varied depending on the starting materials, reagents, etc. used, and is not particularly limited insofar as it dissolves the starting materials to a certain degree without inhibiting the reaction, and preferable examples include ethanol, methanol, tetrahydrofuran, dichloromethane, chloroform, N,N-dimethylformamide, N-methyl pyrrolidone, dimethylsulfoxide and mixed solvents thereof. The reaction is carried out usually at 0 to 120°C.

Step D2 The guanidine derivative used in step D2 is not only easily commercially available but can also be produced by a known method described in e.g. J. Org. Chem., 57, 2497-2502 (1992) or its analogous method. The base used is varied depending on the starting materials, reagents, solvent, etc. used, and is not particularly limited insofar as the reaction is not inhibited, and preferable examples include alkali metal alkoxides (for example, sodium methoxide, sodium ethoxide, potassium tert-butoxide, etc.), alkali metal carbonates (for example, potassium carbonate, sodium carbonate, etc.), etc. The oxidizing agent used is also varied depending on the starting materials, reagents, solvent, etc. used, and is not particularly limited insofar as the reaction is not inhibited, and preferable examples include manganese compounds (for example, activated manganese dioxide, etc.), quinones (for example, 2,3-dichloro-5,6-dicyano-1,4-benzoquinone, etc.), sulfur, etc. The solvent used is varied depending on the starting materials, reagents, etc. used, and is not particularly limited insofar as it dissolves the starting materials to a certain degree without inhibiting the reaction, and preferable examples include ethanol, methanol, tetrahydrofuran, dichloromethane, chloroform, N,N-dimethylformamide, N-methyl pyrrolidone, dimethyl sulfoxide and mixed solvents thereof. The reaction temperature in step D2 is usually 0 to 120°C.

[0054] In the step D1, the formamidine or guanidine derivative may be coexistent from the start in the reaction, and the 2,3-biaryl-2-propenenitrile (8) can be converted without isolation into its corresponding aromatic compound by an oxidizing agent, to produce the pyrimidine derivative (9) in the invention.

Production Method E

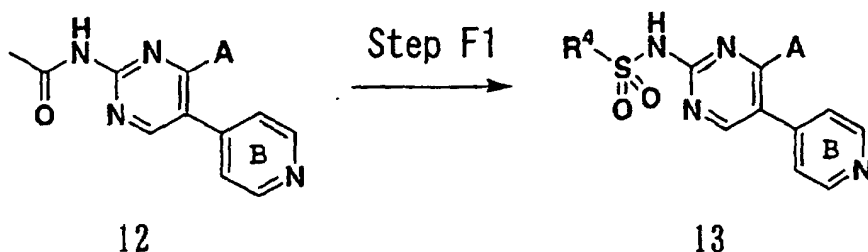


10 wherein A and the ring B have the same meanings as defined above, and R^3 represents a hydrogen atom or a C_{1-6} alkyl group. Step E1 is a step where a carboxylic anhydride is allowed to act on Compound (10) under acidic conditions to acrylate the amino group thereof, whereby the acyl derivative (11) according to the present invention is produced. The starting compound (10) can be produced in Production Method C above, and corresponds to Compound (6) wherein R^1 is an amino group. Step E1 is carried out preferably in the absence of a solvent, but may be conducted after dilution

15 with a solvent. Such a solvent is varied depending on the starting material, reagents, etc. used, and is not particularly limited insofar as it dissolves the starting materials without inhibiting the reaction, and preferable examples are N,N-dimethylformamide, tetrahydrofuran, dioxane, N-methyl pyrrolidone, benzene, toluene, etc. The acid used is varied depending on the starting materials, reagents, solvent, etc. used, and is not particularly limited insofar as it does not inhibit the reaction, and a preferable acid is a mineral acid such as conc. sulfuric acid. The reaction temperature is

20 preferably room temperature to 120°C , more preferably about 90°C .

Production Method F



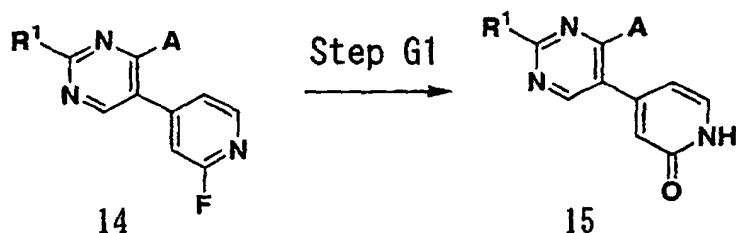
wherein A and the ring B have the same meanings as defined above, and R^4 represents a hydrogen atom or a C_{1-6} alkyl group. The sulfonamide derivative (13) in this invention can be produced by allowing sulfonyl chloride under basic conditions to act on Compound (12) as the starting material (that is, Compound (11) wherein R^3 is a methyl group) which can be produced by Production Method E above, thus sulfonylating Compound (12), and then removing the acyl group under acidic conditions (step F1). The base used in the sulfonylation reaction is varied depending on the starting materials, reagents, solvent, etc. used, and is not particularly limited insofar as the reaction is not inhibited, and preferable examples are sodium hydride, etc. The solvent used in the sulfonylation is varied depending on the starting materials, reagents, etc. used, and is not particularly limited insofar as it dissolves the starting materials to a certain degree without inhibiting the reaction, and preferable examples include ethers such as tetrahydrofuran, dioxane, dimethoxyethane and diethylene glycol. The reaction temperature is preferably -10°C to room temperature. The acid used in the de-acetylation reaction in step F1 is varied depending on the starting materials, reagents, solvent etc. used, and is not particularly limited insofar as the reaction is not inhibited, and a preferable example is hydrochloric acid or the like. The solvent used in the reaction is varied depending on the starting materials, reagents, etc. used, and is not particularly limited insofar as it dissolves the starting materials to a certain degree and is miscible with water to a certain degree without inhibiting the reaction, and a preferable example is a mixed solvent of an ether (for example, tetrahydrofuran) and water. The reaction temperature is preferably room temperature to 100°C .

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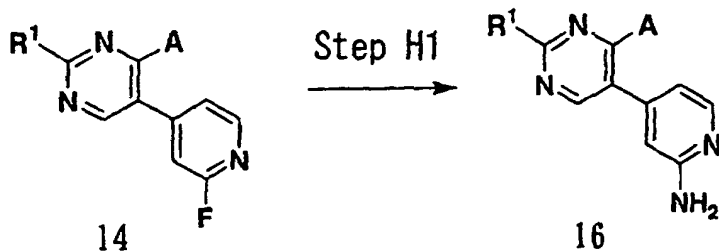
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Production Method G



wherein A and R¹ have the same meanings as defined above. The compound represented by the formula (II) in the present invention can be produced, for example, in the step G1. Compound (14) as the starting material can be produced by Production Method C above. The pyridone derivative (15) according to the present invention can be produced by hydrolyzing the according (14) under acidic conditions. The acid used is varied depending on the starting materials, reagents, solvent, etc. used, and is not particularly limited insofar as the reaction is not inhibited, and preferable examples are hydrochloric acid, hydrobromic acid, sulfuric acid, etc. This reaction is carried out preferably in water, and the reaction temperature is usually room temperature to about 120°C, preferably 100°C.

Production Method H



wherein A and R¹ have the same meanings as defined above. Compound (16) according to the present invention can be produced by allowing ammonia to act on Compound (14) which can be produced by Production Method C above to substitute the fluorine atom by an amino group (step H1). An ammonia gas saturated in a suitable solvent such as ethanol is used as the reagent in this reaction. In this reaction, it is preferable that the reaction solution is sealed in e. g. an autoclave and heated to about 150°C.

[0055] The starting compound in production of Compound (I) or (II) in the present invention may be in the form of a salt or a hydrate and is not particularly limited insofar as the reaction is not inhibited. Further, when Compound (I) or (II) in the invention is obtained in a free form, it can be converted in a usual manner into a salt form which Compound (I) or (II) may form. Further, the resultant isomers (for example, geometric isomer, optical isomer based on asymmetric carbon, stereoisomer, tautomer etc.) of Compound (I) or (II) of the present invention can be purified and isolated by usual separating means, for example recrystallization, diastereomer salt method, enzyme fractionation method, and various kinds of chromatography (for example, thin-layer chromatography, column chromatography, gas chromatography etc.).

Production Examples of the pharmaceutical composition or compound of the present invention

[0056] The pharmaceutical composition of the invention can be manufactured by a conventional method, and preferable preparation forms include tablets, powders, fine granules, granules, coated tablets, capsules, syrups, troches, inhalations, suppositories, injections, ointments, eye ointments, eye drops, nose drops, ear drops, poultices, lotions and the like. Ordinarily used fillers, binders, disintegrating agents, lubricants, coloring agents, flavoring agents, and as necessity, stabilizers, emulsifiers, absorption promoters, surfactants, pH adjusters, preservatives and antioxidants can be used in pharmaceutical manufacturing, and ingredients used generally as starting materials for pharmaceutical preparations can be blended in a usual manner for manufacturing. These ingredients include e.g. (1) animal and vegetable oils such as soybean oil, tallow and synthetic glyceride; (2) hydrocarbons such as liquid paraffin, squalane and solid paraffin; (3) ester oils such as octyldodecyl myristate and isopropyl myristate; (4) higher alcohols such as ceto-stearyl alcohol and behenyl alcohol; (5) silicon resin; (6) silicon oil; (7) surfactants such as polyoxyethylene fatty ester,

sorbitan fatty ester, glycerin fatty ester, polyoxyethylene sorbitan fatty ester, polyoxyethylene hardened castor oil and polyoxyethylene polyoxypropylene block copolymer; (8) water-soluble polymers such as hydroethyl cellulose, polyacrylic acid, carboxyvinyl polymer, polyethylene glycol, polyvinyl pyrrolidone and methyl cellulose; (9) lower alcohols such as ethanol and isopropanol; (10) polyvalent alcohols such as glycerin, propylene glycol, dipropylene glycol and sorbitol; (11) sugars such as glucose and sucrose; (12) inorganic powder such as silicic anhydride, aluminum magnesium silicate and aluminum silicate; and (13) pure water.

[0057] 1) The fillers include e.g. lactose, corn starch, white sugar, glucose, mannitol, sorbitol, crystalline cellulose, silicon dioxide etc.; 2) the binders include e.g. polyvinyl alcohol, polyvinyl ether, methyl cellulose, ethyl cellulose, arabic gum, tragacanth, gelatin, shellac, hydroxy propyl cellulose, hydroxy propylmethyl cellulose, polyvinyl pyrrolidone, polypropylene glycol-polyoxyethylene block polymer, meglumine, calcium citrate, dextrin, pectin etc.; 3) the disintegrating agents include e.g. starch, agar, gelatin powder, crystalline cellulose, calcium carbonate, sodium bicarbonate, calcium citrate, dextrin, pectin, carboxymethyl cellulose calcium etc.; 4) the lubricants include e.g. magnesium stearate, talc, polyethylene glycol, silica, hardened vegetable oil etc.; 5) the coloring agents include e.g. those coloring agents approved to be added to pharmaceutical preparations; 6) the flavoring agents include cocoa powder, menthol, aromatic powder, peppermint oil, borneol, cinnamon powder etc.; and 7) the antioxidants include those approved to be added to pharmaceutical preparations, such as ascorbic acid and α -tocopherol.

[0058] 1) The oral preparation is produced by mixing the active ingredient with fillers and if necessary with a binder, a disintegrating agent, a lubricant, a coloring agent, a flavoring agent etc., and then forming it in a usual manner into powders, fine granules, granules, tablets, coated tablets, capsules, etc. 2) The tablets and granules may be coated with a sugar or gelatin coating or if necessary with another suitable coating. 3) The liquid preparations such as syrups, injections and eye drops are prepared by mixing the active agent with a pH adjuster, a solubilizer and an isotonicizing agent etc., and with a solubilizing aid, a stabilizer, a buffer, a suspension agent, an antioxidant etc. if necessary, followed by forming it into a preparation in a usual manner. The liquid preparation may be formed into a freeze-dried product and the injection can be administered intravenously, subcutaneously or intramuscularly. Preferable examples of the suspension agent include methyl cellulose, Polysorbate 80, hydroxyethyl cellulose, arabic gum, tragacanth powder, sodium carboxymethyl cellulose, polyoxyethylene sorbitan monolaurate etc.; preferable examples of the solubilizing aid include polyoxyethylene hardened castor oil, Polysorbate 80, nicotinamide, polyoxyethylene sorbitan monolaurate etc.; preferable examples of the stabilizer include sodium sulfite, sodium metabisulfite, ether etc.; preferable examples of the preservative include methyl p-oxybenzoate, ethyl p-oxybenzoate, sorbic acid, phenol, cresol, chlorocresol etc. 4) The agent for external application can be produced in any conventional method. That is, the starting base material can make use of various starting materials ordinarily used in pharmaceutical preparations, non-pharmaceutical preparations, cosmetics, etc. For example, the material includes animal and vegetable oils, mineral oil, ester oil, waxes, higher alcohols, fatty acids, silicon oil, surfactants, phospholipids, alcohols, polyvalent alcohols, water-soluble polymers, clay minerals, pure water etc. If necessary, a pH adjuster, an antioxidant, a chelating agent, a preservative, a coloring agent, a perfume etc. can further be added. Further, ingredients having a differentiation-inducing action, a blood-stream promoting agent, a sterilizer, an antiinflammatory agent, a cell activator, vitamins, amino acids, a humectant, a keratin solubilizer etc. can also be incorporated as necessity.

[0059] Although the dose of the pharmaceutical composition or compound according to the present invention is varied depending on severity of symptoms, age, sex, body weight, administration form, type of salt, chemical sensitivity, specific type of disease etc., it is given daily in one portion or in divided portions into an adult in a dose of usually about 30 μ g to 10 g, preferably 100 μ g to 5 g, more preferably 100 μ g to 100 mg for oral administration, or about 30 μ g to 1 g, preferably 100 μ g to 500 mg, more preferably 100 μ g to 30 mg for injection.

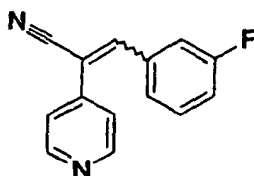
[0060] Accordingly to this invention, there can be provided a novel pharmaceutical composition promoting defecation. The defecation-promoting agent according to the present invention is useful as a pharmaceutical preparation promoting physiological defecation. According to the present invention, there can also be provided a novel pyrimidine compound and a salt thereof. The compound or a salt thereof is useful as a pharmaceutical preparation exhibiting an excellent antagonistic action on adenosine A_2 receptor, particularly on A_{2b} receptor, and simultaneously promoting defecation. Accordingly, the defecation-promoting pharmaceutical composition according to the present invention and the compound of the present invention are useful as an agent for treating, preventing or improving various kinds of constipation, for example functional constipation (acute constipation and various kinds of chronic constipation (for example, atonic constipation, spastic constipation, dyschezia, rectal constipation, chemically inducible constipation etc.)), organic constipation, enteroparalytic ileus, IBS, constipation accompanying IBS, constipation accompanying congenital digestive tract dysfunction, constipation accompanying ileus etc. Further, use of the defecation-promoting agent according to the present invention as a pharmaceutical preparation is not limited to the treatment, prevention or improvement of various kinds of constipation, but it is also useful as a chemical for evacuating intestinal tracts at the time of examination of digestive tracts or before and after an operation, as an aid for defecation after an operation, as a chemical for promotion of defecation after administering a contrast medium, and as a defecation-promoting agent when the patient is hypertensive or has a dangerous of cerebral apoplexy, cerebral infarction, cardiac infarction, etc.

Examples

[0061] As examples of the active ingredient in the pharmaceutical composition promoting defecation according to the present invention, the best mode except for the previously described known compounds is described. The following examples are described merely for illustrative purposes, and not intended to limit the compounds as the active ingredient in the pharmaceutical composition of the invention.

Reference Example 1 3-(3-Fluorophenyl)-2-(4-pyridyl)-2-propene nitrile

[0062]

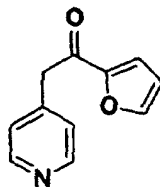


[0063] After sodium (3.0 g, 130 mmol) was dissolved in ethanol (150 mL), 4-pyridyl acetonitrile hydrochloride (33 g, 121 mmol) was added thereto and stirred at room temperature. After 10 minutes, 3-fluorobenzaldehyde (8 g, 65 mmol) was added thereto and stirred as such for 30 minutes. The resulting precipitates were collected by filtration and washed with a small amount of water, to give the title compound (8.2 g, 56 %) as a colorless solid.

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm; 7.40-7.46 (1H, m), 7.61-7.68 (1H, m), 7.75 (2H, dd, *J* = 1.6, 4.4 Hz), 7.77-7.86 (2H, m), 8.37 (1H, s), 8.73 (2H, dd, *J* = 1.6, 4.4 Hz).

Reference Example 2 1-(2-Furyl)-2-(4-pyridyl)-1-ethanone

[0064]

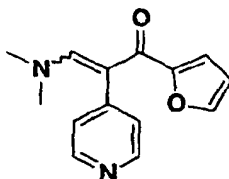


[0065] Lithium bis(trimethylsilyl)amide (100 mL, 100 mmol) was added dropwise over 1 hour to a solution of 4-picoline (4.6 g, 49.4 mmol) and ethyl 2-furancarboxylate (7.7 g, 54.9 mmol) in tetrahydrofuran (40 mL) at 0°C in a nitrogen atmosphere, followed by stirring as such for 2 hours. Hexane (140 mL) was added to the reaction solution, and the resulting crystals were collected by filtration. The resulting crystals were dissolved in ethyl acetate and an aqueous saturated ammonium chloride solution. The organic layer was washed with an aqueous saturated ammonium chloride solution (×2) and brine, dried over anhydrous sodium sulfate, and concentrated. Hexane was added to the residue, and the resulting precipitates were collected by filtration and washed with hexane, to give the title compound (6.5 g, 70 %) as a pale yellow solid.

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm; 4.26 (2H, s), 6.77 (1H, dd, *J* = 2.0, 3.6 Hz), 7.31 (2H, dd, *J* = 1.6, 4.4 Hz), 7.65 (1H, dd, *J* = 0.8, 3.6 Hz), 8.05 (1H, dd, *J* = 0.8, 2.0 Hz), 8.51 (2H, dd, *J* = 1.6, 4.4 Hz).

Reference Example 3 3-(Dimethylamino)-1-(2-furyl)-2-(4-pyridyl)-2-propene-1-one

[0066]



[0067] N,N-dimethylformamide dimethyl acetal (5 mL) was added to 1-(2-furyl)-2-(4-pyridyl)-1-ethanone (2.0 g, 10.7 mmol) and stirred at 100°C for 2 hours. After cooling as it was, the reaction mixture was diluted with ethyl acetate and an aqueous saturated ammonium chloride solution. The aqueous layer was extracted with ethyl acetate (×6). The combined organic layer was dried over anhydrous sodium sulfate and concentrated, to give the title compound (2.5 g, 97 %) as a reddish brown oil.

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm; 2.80 (6H, br s), 6.53 (1H, br), 6.60 (1H, br), 7.10 (2H, d, *J* = 4.0 Hz), 7.65 (1H, br), 7.75 (1H, s), 8.44 (2H, d, *J* = 4.0 Hz).

Example 1 6-(3-Fluorophenyl)-5-(4-pyridyl)-2,4-pyrimidine diamine

[0068] After sodium (6.2 g, 268 mmol) was dissolved in ethanol (700 mL), 3-(3-fluorophenyl)-2-(4-pyridyl)-2-propene nitrile (50 g, 223 mmol) and guanidine hydrochloride (25.6 g, 268 mmol) were added thereto in this order and heated under reflux for 4 hours. After cooling as it was, the solvent was removed. Tetrahydrofuran (500 mL) was added to the residue, the insoluble matters were filtered off, and the filtrate was concentrated. A suspension of the residues and activated manganese dioxide (200 g) in chloroform (1000 mL) was heated under reflux for 2 hours. After cooling as it was, the manganese dioxide was filtered off through Celite, and washed with tetrahydrofuran (500 mL×3) and methanol-chloroform (1:1) (1000 mL×2). The collected filtrate was concentrated, and then methanol was added to the residue. The resulting precipitates were collected by filtration, to give the title compound as a crude solid (14.6 g). The crude crystals were recrystallized from methanol-chloroform, to give the title compound (12.4 g, 20 %) as a colorless solid. ¹H NMR (400 MHz, DMSO-*d*₆) δ ppm; 6.03 (2H, br s), 6.22 (2H, br s), 6.90-7.00 (2H, m), 7.01-7.12 (1H, m), 7.08 (2H, d, *J* = 5.6 Hz), 7.16-7.23 (1H, m), 8.43 (2H, d, *J* = 5.6 Hz); MS *m/e* (ESI) 282 (MH⁺).

Example 2 6-(2-Furyl)-5-(4-pyridyl)-2,4-pyrimidinediamine.

[0069] After sodium (3.2 g, 139 mmol) was dissolved in anhydrous ethanol (200 mL), 4-pyridyl acetonitrile hydrochloride (10.0 g, 64 mmol) and 2-furaldehyde (6.1 mL, 73.6 mmol) and guanidine hydrochloride (7.0 g, 73.3 mmol) were successively added thereto. After stirring at room temperature for 1 hour, it was heated under reflux for 7 hours. After cooling as it was, the insoluble matters were filtered off, washed with tetrahydrofuran, and the solvent was removed from the filtrate. Tetrahydrofuran (200 mL) and activated manganese dioxide (30.0 g) were added to the residue, followed by heating under reflux for 2.5 hours. After cooling as it was, the manganese dioxide was filtered through Celite, and washed with tetrahydrofuran. The collected filtrate was concentrated, and then methanol was added to the residues. The resulting precipitates were collected by filtration and washed with methanol, to give the title compound (3.48 g, 21 %) as a pale brown solid.

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm; 5.88 (2H, br s), 6.15 (2H, br s), 6.18 (1H, d, *J* = 3.2 Hz), 6.38 (1H, dd, *J* = 1.8, 3.2 Hz), 7.18 (2H, dd, *J* = 1.4, 4.4 Hz), 7.47-7.51 (1H, m), 8.59 (2H, dd, *J* = 1.4, 4.4 Hz).

Example 3 4-(2-Furyl)-5-(4-pyridyl)-2-pyrimidinyl amine

[0070] A suspension of 3-(dimethylamino)-1-(2-furyl)-2-(4-pyridyl)-2-propene-1-one (2.2 g, 9.08 mmol), guanidine hydrochloride (2.6 g, 27.2 mmol) and potassium carbonate (7.5 g, 54.3 mmol) in N,N-dimethylformamide (20 mL) was stirred at 70°C for 12 hours. After cooling as it was, the reaction mixture was diluted with water. The resulting crystals were collected by filtration and washed with water, to give the title compound (1.73 g, 80 %) as a pale yellow solid.

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm; 6.56 (1H, dd, *J* = 1.6, 3.6 Hz), 6.68 (1H, dd, *J* = 0.8, 3.6 Hz), 6.98 (2H, br s), 7.27 (2H, dd, *J* = 1.6, 4.4 Hz), 7.67 (1H, dd, *J* = 0.8, 1.6 Hz), 8.22 (1H, s), 8.56 (2H, dd, *J* = 1.6, 4.4 Hz); MS *m/e* (ESI) 239 (MH⁺).

Example 4 4-(3-Fluorophenyl)-5-(4-pyridyl)-2-pyrimidinylamine

[0071] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm; 7.04-7.07 (1H, m), 7.10 (2H, br s), 7.12-7.18 (1H, m), 7.14 (2H, dd, *J* = 1.6, 4.4 Hz), 7.20-7.26 (1H, m), 7.32-7.38 (1H, m), 8.38 (1H, s), 8.45 (2H, dd, *J* = 1.6, 4.4 Hz); MS *m/e* (ESI) 267 (MH⁺).

Example 5 4-Phenyl-5-(4-pyridyl)-2-pyrimidinylamine

[0072] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm; 7.04 (2H, br s), 7.10 (2H, d, *J* = 5.4 Hz), 7.28-7.41 (5H, m), 8.36 (1H, s), 8.42 (2H, d, *J* = 5.4 Hz); MS *m/e* (ESI) 249 (MH⁺).

Example 6 5-(4-Pyridyl)-4-(2-thienyl)-2-pyrimidinylamine

[0073] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm; 6.70 (1H, dd, *J* = 1.2, 3.8 Hz), 6.94 (1H, dd, *J* = 3.8, 5.2 Hz), 6.97 (2H, br s), 7.37 (2H, dd, *J* = 1.6, 4.4 Hz), 7.67 (1H, dd, *J* = 1.2, 5.2 Hz), 8.16 (1H, s), 8.61 (2H, dd, *J* = 1.6, 4.4 Hz); MS *m/e* (ESI) 255 (MH⁺).

Example 7 4-(2-Pyridyl)-5-(4-pyridyl)-2-pyrimidinylamine

[0074] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm; 7.02 (2H, dd, *J* = 1.6, 4.6 Hz), 7.09 (2H, br s), 7.37-7.41 (1H, m), 7.71-7.75 (1H, m), 7.88-7.93 (1H, m), 8.34-8.37 (1H, m), 8.37 (2H, dd, *J* = 1.6, 4.6 Hz), 8.42 (1H, s); MS *m/e* (ESI) 250 (MH⁺).

Example 8 4-(3-Fluorophenyl)-5-(4-pyridyl)pyrimidine

[0075] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm; 7.08-7.15 (2H, m), 7.17 (2H, dd, *J* = 1.6, 4.4 Hz), 7.22-7.31 (2H, m), 8.64 (2H, dd, *J* = 1.6, 4.4 Hz), 8.77 (1H, s), 9.33 (1H, m); MS *m/e* (ESI) 252 (MH⁺).

Example 9 4-(3-Fluorophenyl)-5-(2-fluoro-4-pyridyl)pyrimidine

[0076] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (FAB) 270 (MH⁺).

Example 10 4-(3-Fluorophenyl)-5-(2-fluoro-4-pyridyl)-2-pyrimidinyl amine

[0077] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (FAB) 285 (MH⁺).

Example 11 N-[4-(3-Fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]-N,N-dimethylamine

[0078] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 295 (MH⁺).

Example 12 N-[4-(3-Fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]-N-methylamine

[0079] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 281 (MH⁺).

Example 13 4-[4-(3-Fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]morpholine

[0080] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 337 (MH⁺).

Example 14 N-[4-(3-Fluorophenyl)-5-(2-fluoro-4-pyridyl)-2-pyrimidinyl]-N-methylamine

[0081] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (FAB) 299 (MH⁺).

Example 15 4-[4-(3-Fluorophenyl)-2-(methylamino)-5-pyrimidinyl]-1,2-dihydro-2-pyridinone

[0082] A mixture of N-[4-(3-fluorophenyl)-5-(2-fluoro-4-pyridyl)-2-pyrimidinyl]-N-methylamine (30 mg, 0.101 mmol) and 6 N hydrochloric acid (3 mL) was heated under reflux for 40 minutes. The reaction solution was cooled as it was, and then washed with ethyl acetate. The aqueous layer was neutralized with 5 N aqueous sodium hydroxide, and then extracted with ethyl acetate, dried over anhydrous sodium sulfate and concentrated. The residue was suspended in diethyl ether, and then the resulting solid was collected by filtration and washed with diethyl ether, to give the title compound (20 mg, 67 %).

MS *m/e* (FAB) 297 (MH⁺).

Example 16 N-Ethyl-N-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]amine

[0083] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (FAB) 295 (MH⁺).

Example 17 N1-[4-(3-Fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]acetamide

[0084] A mixture of 4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinylamine (200 mg, 0.751 mmol), acetic anhydride (6 mL) and conc. sulfuric acid (4 drops) was stirred at 90°C for 16 hours. After cooling as it was, the reaction solution was diluted with ethyl acetate, water and a saturated aqueous sodium bicarbonate solution. The organic layer was washed with saturated sodium bicarbonate (×2) and brine, and then dried over anhydrous sodium sulfate and concentrated. The residue was suspended in diethyl ether, and then the resulting solid was collected by filtration and washed with diethyl ether, to give the title compound (126 mg, 54 %).

MS *m/e* (FAB) 309 (MH⁺).

Example 18 N1-[4-(3-Fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]-N1-methylacetamide

[0085] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3, Example 3 and Example 17.

MS *m/e* (FAB) 323 (MH⁺).

Example 19 N1-[4-(3-Fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]propanamide

[0086] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3, Example 3 and Example 17.

MS *m/e* (FAB) 323 (MH⁺).

Example 20 N1-[4-(3-Fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]butanamide

[0087] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3, Example 3 and Example 17.

MS *m/e* (FAB) 337 (MH⁺).

Example 21 N1-[4-(3-Fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]-N1-methylpropanamide

[0088] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3, Example 3 and Example 17.

MS *m/e* (FAB) 337 (MH⁺).

Example 22 4-(3-Fluorophenyl)-5-(2-methyl-4-pyridyl)-2-pyrimidinylamine

[0089] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (FAB) 281 (MH⁺).

Example 23 N1-Ethyl-N1-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]propanamide

[0090] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3, Example 3 and Example 17.

MS *m/e* (FAB) 351 (MH⁺).

Example 24 N1-[4-(3-Fluorophenyl)-5-(2-fluoro-4-pyridyl)-2-pyrimidinyl]propanamide

[0091] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3, Example 3 and Example 17.

MS *m/e* (FAB) 341 (MH⁺).

Example 25 N1-[4-(3-Fluorophenyl)-5-(2-methyl-4-pyridyl)-2-pyrimidinyl]propanamide

[0092] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3, Example 3 and Example 17.

MS *m/e* (FAB) 337 (MH⁺).

Example 26 4-[2-Amino-4-(3-fluorophenyl)-5-pyrimidinyl]-1,2-dihydro-2-pyridinone

[0093] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3, Example 3 and Example 15.

MS *m/e* (FAB) 283 (MH⁺).

Example 27 N-Ethyl-N-[4-(3-fluorophenyl)-5-(2-fluoro-4-pyridyl)-2-pyrimidinyl]amine

[0094] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (FAB) 313 (MH⁺).

Example 28 4-[2-(Ethylamino)-4-(3-fluorophenyl)-5-pyrimidinyl]-1,2-dihydro-2-pyridinone

[0095] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3, Example 3 and Example 15.

MS *m/e* (FAB) 311 (MH⁺).

Example 29 N-[4-(3-Fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]-N-propylamine

[0096] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 309 (MH⁺).

Example 30 N-[4-(3-Fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]-N-phenylamine

[0097] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 343 (MH⁺).

Example 31 N-Ethyl-N-[4-(3-fluorophenyl)-5-(2-methyl-4-pyridyl)-2-pyrimidinyl]amine

[0098] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 309 (MH⁺).

Example 32 5-(2,6-Dimethyl-4-pyridyl)-4-(3-fluorophenyl)-2-pyrimidinylamine

[0099] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 295 (MH⁺).

Example 33 N-[5-(2,6-Dimethyl-4-pyridyl)-4-(3-fluorophenyl)-2-pyrimidinyl]-N-ethylamine

[0100] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 323 (MH⁺).

Example 34 4-(3-Fluorophenyl)-5-(3-methyl-4-pyridyl)-2-pyrimidinylamine

[0101] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (FAB) 281 (MH⁺).

Example 35 5-(3-Ethyl-4-pyridyl)-4-(3-fluorophenyl)-2-pyrimidinylamine

[0102] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (FAB) 295 (MH⁺).

Example 36 5-(2-Amino-4-pyridyl)-4-(3-fluorophenyl)-2-pyrimidinylamine

[0103] A mixture of 4-(3-fluorophenyl)-5-(2-fluoro-4-pyridyl)-2-pyrimidinylamine (100 mg, 0.352 mmol) and ammonia/ethanol (ethanol saturated with an ammonia gas under ice-cooling) (20 mL) was sealed in a test tube and stirred at 150°C for 2 weeks. After cooling as it was, the reaction solution was concentrated. The residue was dissolved by adding ethyl acetate and water thereto. The organic layer was washed with water and brine, and then dried over anhydrous sodium sulfate and concentrated. The residue was purified by TLC plate (eluting solvent: dichloromethane/methanol=10/1), to give the title compound (12 mg, 12 %).

MS *m/e* (FAB) 282 (MH⁺).

Example 37 N4-Methyl-6-(3-fluorophenyl)-5-(4-pyridyl)-2,4-pyrimidinediamine

[0104] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 296 (MH⁺).

Example 38 N4,N4-Dimethyl-6-(3-fluorophenyl)-5-(4-pyridyl)-2,4-pyrimidinediamine

[0105] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 310 (MH⁺).

Example 39 N-Ethyl-N- [4-(2-furyl)-5-(4-pyridyl)-2-pyrimidinyl]amine

5 **[0106]** The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.
MS *m/e* (ESI) 267 (MH⁺).

Example 40 N-Ethyl-N-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]amine

10 **[0107]** The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.
MS *m/e* (ESI) 310 (MH⁺).

15 Example 41 N-Ethyl-N-[4-phenyl-5-(4-pyridyl)-2-pyrimidinyl]amine

[0108] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.
MS *m/e* (ESI) 277 (MH⁺).

20 Example 42 N-Ethyl-N-[5-(4-pyridyl)-4-(2-thienyl)-2-pyrimidinyl]amine

[0109] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.
25 MS *m/e* (ESI) 283 (MH⁺).

Example 43 5-(3-Ethyl-4-pyridyl)-4-(2-furyl)-2-pyrimidinylamine

[0110] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.
30 MS *m/e* (ESI) 267 (MH⁺).

Example 44 N-Ethyl-N-[5-(3-ethyl-4-pyridyl)-4-(2-furyl)-2-pyrimidinyl]amine

35 **[0111]** The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.
MS *m/e* (ESI) 295 (MH⁺).

Example 45 4-(2,5-Dimethyl-3-furyl)-5-(3-ethyl-4-pyridyl)-2-pyrimidinylamine

40 **[0112]** The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.
MS *m/e* (ESI) 267 (MH⁺).

45 Example 46 N-[4-(2,5-Dimethyl-3-furyl)-5-(3-ethyl-4-pyridyl)-2-pyrimidinyl]-N-ethylamine

[0113] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.
MS *m/e* (ESI) 295 (MH⁺).

50 Example 47 5-(2,6-Dimethyl-4-pyridyl)-6-(3-fluorophenyl)-2,4-pyrimidinediamine

[0114] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.
55 MS *m/e* (ESI) 310 (MH⁺).

Example 48 4-(3-Methyl-2-furyl)-5-(4-pyridyl)-2-pyrimidinylamine

[0115] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 253 (MH⁺).

Example 49 N-[4-(3-Fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]methanesulfonamide

[0116] 60 % oily sodium hydride (20 mg, 0.500 mmol) was added to a solution of N1-[4-(3-fluorophenyl)-5-(4-pyridyl)-2-pyrimidinyl]acetamide (100 mg, 0.324 mmol) in tetrahydrofuran (10 mL) under ice-cooling in a nitrogen atmosphere. After stirring the reaction solution as it was for 20 minutes, methanesulfonyl chloride (30 μ L, 0.388 mmol) was added dropwise thereto and stirred at room temperature. After 1 hour, 60 % oily sodium hydride (20 mg, 0.500 mmol) and methanesulfonyl chloride (30 μ L, 0.388 mmol) were additionally added thereto under ice-cooling, and further stirred at room temperature for 1 hour. The reaction solution was diluted with ethyl acetate and a saturated aqueous ammonium chloride solution. The organic layer was washed with a saturated aqueous ammonium chloride solution, a saturated aqueous sodium bicarbonate solution and a saturated aqueous ammonium chloride solution, and then dried over anhydrous sodium sulfate and concentrated. The residues were purified by TLC plate (eluting solvent: dichloromethane/methanol=10/1), to give a starting sulfonamide compound (70 mg). To the product were added tetrahydrofuran (10 mL) and 1 N hydrochloric acid (1 mL), followed by heating under reflux for 1 hour. After cooling as it was, the reaction solution was concentrated. The residue was suspended in diethyl ether, and then the resulting solid was collected by filtration and washed with diethyl ether, to give the title compound (68 mg, 55 %) as hydrochloride.

MS *m/e* (ESI) 345 (MH⁺).

Example 50 4,5-Di(4-pyridyl)-2-pyrimidinylamine

[0117] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 250 (MH⁺).

Example 51 4-(4-Methoxyphenyl)-5-(4-pyridyl)-2-pyrimidinylamine

[0118] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 279 (MH⁺).

Example 52 4-(3,4-Dimethoxyphenyl)-5-(4-pyridyl)-2-pyrimidinylamine

[0119] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 309 (MH⁺).

Example 53 4-[2-Amino-5-(4-pyridyl)-4-pyrimidinyl]phenol

[0120] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 265 (MH⁺).

Example 54 Methyl 3-[2-amino-5-(4-pyridyl)-4-pyrimidinyl]benzoate

[0121] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 307 (MH⁺).

Example 55 N4,N4-Dimethyl-6-(2-furyl)-5-(4-pyridyl)-2,4-pyrimidinediamine

[0122] The title compound was synthesized in an identical or analogous method to that of Reference Example 2, Reference Example 3 and Example 3.

MS *m/e* (ESI) 282 (MH⁺)

Table 9



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Ex. No.	a	b	c	d
1	-NH ₂	3-F-Ph	4-Py	-NH ₂
2	-NH ₂	2-Furyl	4-Py	-NH ₂
3	-NH ₂	2-Furyl	4-Py	-H
4	-NH ₂	3-F-Ph	4-Py	-H
5	-NH ₂	Ph	4-Py	-H
6	-NH ₂	2-Thienyl	4-Py	-H
7	-NH ₂	2-Py	4-Py	-H
8	-H	3-F-Ph	4-Py	-H
9	-H	3-F-Ph	2-F-4-Py	-H
10	-NH ₂	3-F-Ph	2-F-4-Py	-H
11	-NMe ₂	3-F-Ph	4-Py	-H
12	-NHMe	3-F-Ph	4-Py	-H
13	-(4-Morpholinyl)	3-F-Ph	4-Py	-H
14	-NHMe	3-F-Ph	2-F-4-Py	-H
15	-NHMe	3-F-Ph	1,2-2H-2-pyridinone-4-yl	-H
16	-NHEt	3-F-Ph	4-Py	-H
17	-NHCOMe	3-F-Ph	4-Py	-H
18	-N(Me)COMe	3-F-Ph	4-Py	-H
19	-NHCOEt	3-F-Ph	4-Py	-H
20	-NHCON-Pr	3-F-Ph	4-Py	-H

2 1	-N(Me)COEt	3-F-Ph	4-Py	-H
2 2	-NH ₂	3-F-Ph	2-Me-4-Py	-H
2 3	-N(Et)COEt	3-F-Ph	4-Py	-H
2 4	-NHCOEt	3-F-Ph	2-F-4-Py	-H
2 5	-NHCOEt	3-F-Ph	2-Me-4-Py	-H
2 6	-NH ₂	3-F-Ph	1, 2-2H-2-pyridinone-4-yl	-H
2 7	-NHEt	3-F-Ph	2-F-4-Py	-H
2 8	-NHEt	3-F-Ph	1, 2-2H-2-pyridinone-4-yl	-H
2 9	-NHn-Pr	3-F-Ph	4-Py	-H
3 0	-NHPh	3-F-Ph	4-Py	-H
3 1	-NHEt	3-F-Ph	2-Me-4-Py	-H
3 2	-NH ₂	3-F-Ph	2, 6-DiMe-4-Py	-H
3 3	-NHEt	3-F-Ph	2, 6-DiMe-4-Py	-H
3 4	-NH ₂	3-F-Ph	3-Me-4-Py	-H
3 5	-NH ₂	3-F-Ph	3-Et-4-Py	-H
3 6	-NH ₂	3-F-Ph	2-NH ₂ -4-Py	-H
3 7	-NH ₂	3-F-Ph	4-Py	-NHMe
3 8	-NH ₂	3-F-Ph	4-Py	-NMe ₂
3 9	-NHEt	2-Furyl	4-Py	-H
4 0	-NHEt	3-f-Ph	4-Py	-H
4 1	-NHEt	Ph	4-Py	-H
4 2	-NHEt	2-Thienyl	4-Py	-H

43	-NH ₂	2-Furyl	3-Et-4-Py	-H
44	-NHEt	2-Furyl	3-Et-4-Py	-H
45	-NH ₂	2,5-Dimethyl-3-furyl	3-Et-4-Py	-H
46	-NHEt	2,5-Dimethyl-3-furyl	3-Et-4-Py	-H
47	-NH ₂	3-F-Ph	2,6-DiMe-4-Py	-NH ₂
48	-NH ₂	3-Methyl-2-furyl	4-Py	-H
49	-NHSO ₂ Me	3-F-Ph	4-Py	-H
50	-NH ₂	4-Py	4-Py	-H
51	-NH ₂	4-MeO-Ph	4-Py	-H
52	-NH ₂	3,4-DiMeO-Ph	4-Py	-H
53	-NH ₂	4-OH-Ph	4-Py	-H
54	-NH ₂	3-Methoxycarbonyl-Ph	4-Py	-H
55	-NH ₂	2-Furyl	4-Py	-NMe ₂

In the table above, Ph. means a phenyl group; Py, pyridyl group; Me, methyl group; Et, ethyl group; DiMe, dimethyl group; n-Pr, n-propyl group; F, fluorine atom (fluoro); MeO, methoxy group; DiMeO, dimethoxy group; OH, hydroxyl group; and 2H, dihydro, respectively.

Evaluation of Defecation-Promoting Action

[0123] The defecation-promoting action of the adenosine A_{2b} receptor-inhibiting compound which was identified by measuring the binding ability and inhibitory ability thereof to the adenosine receptor in the above method, a salt thereof, a hydrate of them, or a pharmaceutical composition containing it can be evaluated on the basis of the method described in this specification.

[0124] That is, SD IGS rats (6- to 7-weeks-old, from Charles River) were placed in cages (3 animals/cage) and preliminarily allowed food and water ad libitum and raised for 1 week. On the day of the experiment, their weight was measured, a water-absorbing sheet was placed below each cage, and the animals were fasted but allowed water ad libitum throughout the experiment. Three hours after fasting was initiated, the fecal pellets were recovered from each cage and observed for abnormality before the experiment, and then the compound suspended in 0.5 % (w/v) methyl cellulose (MC) was orally administered in a dose of 5 ml/kg. On one hand, 0.5 % (w/v) MC only was orally given to the control group. After administration of the compound, the rats were returned to the cage provided with a new water-absorbing sheet, and 180 minutes after the administration, the fecal pellets on the water-absorbing sheet were recovered from each cage, and the external appearance was observed, and the number of fecal pellets was counted. The number of fecal pellets is expressed per each cage. Both compounds (I) and (II) in the invention exhibited an excellent adenosine A_2 receptor antagonism, and exhibited an excellent antagonism particularly to an adenosine A_{2b} receptor. Further, both compounds (I) and (II) exhibited an excellent defecation-promoting action. The defecation-promoting action of the title compound in Example 1 is shown below. The defecation-promoting action of the title compound in Example 3 is as shown in the above tables.

Table 10

Compound	Dose	The number of fecal pellets/3 rats	
Control	-	4.67±1.26	
Example 1	3 mg/kg	14.83±1.82	**
	10 mg/kg	23.17±2.94	***

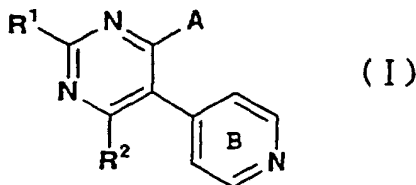
The number of cages; n=6 cages/group (18 rats/group)

**p<0.01,

***p<0.001, NS; not significant, Dunnett's test

Claims

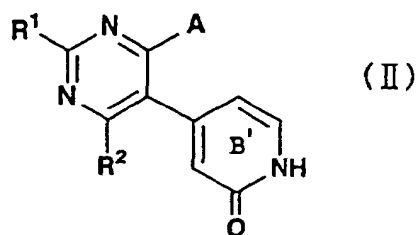
1. A compound represented by the formula:



(wherein A represents a phenyl group, pyridyl group, thienyl group or furyl group which may be substituted with one or two groups selected from a halogen atom, a hydroxyl group, a C_{1-6} alkyl group, a C_{1-6} alkoxy group and a C_{1-6} alkoxy-carbonyl group; B represents a pyridyl group which may be substituted with one or more groups selected from a halogen atom, hydroxyl group, a C_{1-6} alkyl group and amino group; R^1 represents a hydrogen atom, a morpholinyl group or a group represented by the formula $-NR^{1a}R^{1b}$ (wherein R^{1a} and R^{1b} are the same as or different from each other and each represents a hydrogen atom, a C_{1-6} alkyl group, a C_{1-6} acyl group, a phenyl group or a C_{1-6} alkylsulfonyl group); and R^2 represents a hydrogen atom or a group represented by the formula $-NR^{2a}R^{2b}$ (wherein R^{2a} and R^{2b} are the same as or different from each other and each represents a hydrogen atom or a C_{1-6} alkyl group),

provided that, in the above definition, the cases (i) where, A is a 4-fluorophenyl group; B is a 4-pyridyl group; R^1 is an amino group; and R^2 is a hydrogen atom, and (ii) where, A is a 4-fluorophenyl group; B is a 4-pyridyl group, R^1 is an acetamide group; and R^2 is a hydrogen atom are excluded) or a salt thereof.

2. A compound represented by the formula:

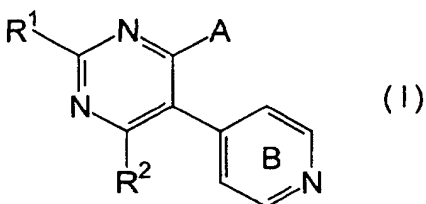


15 (wherein A, R¹ and R² have the same meanings as defined in claim 1; and B' represents a 1,2-dihydro-2-pyridinone-4-yl group which may be substituted with one or more groups selected from a halogen atom, hydroxyl group, a C₁₋₆ alkyl group and amino group) or a salt thereof.

- 20 3. A pharmaceutical composition comprising the compound according to claim 1 or 2, or a salt of them.
4. The composition according to claim 3, which is an adenosine A_{2b} receptor antagonist.
- 25 5. The composition according to claim 3, which is a defecation-promoting agent.
6. The composition according to claim 3, which is an agent for treating, preventing or improving constipation.
7. The composition according to claim 3, which is an agent for treating, preventing or improving functional constipation.
8. The composition according to claim 7, wherein the functional constipation is spastic constipation or atonic constipation.
- 30 9. The composition according to claim 3, which is an agent for treating, preventing or improving irritable bowel syndrome or constipation accompanying irritable bowel syndrome.
10. The composition according to claim 3 which is an agent for treating, preventing or improving organic constipation, constipation accompanying enteroparalytic ileus, constipation accompanying congenital digestive tract dysfunction or constipation accompanying ileus.
- 35 11. The composition according to claim 3, which is for evacuating intestinal tracts at the time of examination of digestive tracts or before and after an operation.
- 40 12. Use of the compound described in claim 1 or 2 or a salt thereof for producing a defecation-promoting agent.
13. Use of the compound described in claim 1 or 2 or a salt thereof for producing an agent for treating, preventing or improving constipation.
- 45 14. Use of a pharmacologically effective amount of the compound described in claim 1 or 2 or a salt thereof for the manufacture of a pharmaceutical composition for promotion of defecation.
15. Use of a pharmacologically effective amount of the compound described in claim 1 or 2 or a salt thereof for the manufacture of a pharmaceutical composition for treating, preventing or improving constipation.
- 50

Patentansprüche

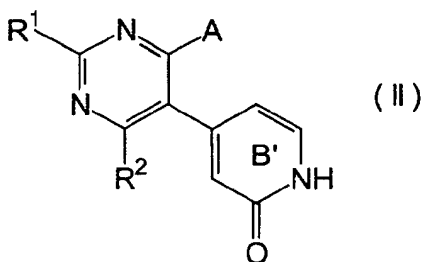
- 55 1. Verbindung mit der Formel:



10 [worin A eine Phenylgruppe, Pyridylgruppe, Thienylgruppe oder Furylgruppe bedeutet, die mit einer oder zwei Gruppen substituiert sein kann, die ausgewählt sind aus einem Halogenatom, einer Hydroxylgruppe, einer C₁₋₆-Alkylgruppe, einer C₁₋₆-Alkoxygruppe und einer C₁₋₆-Alkoxycarbonylgruppe; B eine Pyridylgruppe bedeutet, die mit einer oder mehreren Gruppen substituiert sein kann, die ausgewählt sind aus einem Halogenatom, einer Hydroxylgruppe, einer C₁₋₆-Alkylgruppe und einer Aminogruppe; R¹ ein Wasserstoffatom, eine Morpholinylgruppe oder eine Gruppe mit der Formel -NR^{1a}R^{1b} (worin R^{1a} und R^{1b} gleich oder verschieden voneinander sind und jeweils ein Wasserstoffatom, eine C₁₋₆-Alkylgruppe, eine C₁₋₆-Acylgruppe, eine Phenylgruppe oder eine C₁₋₆-Alkylsulfonylgruppe bedeuten) bedeutet; und R² ein Wasserstoffatom oder eine Gruppe mit der Formel -NR^{2a}R^{2b} (worin R^{2a} und R^{2b} gleich oder verschieden voneinander sind und jeweils ein Wasserstoffatom oder eine C₁₋₆-Alkylgruppe bedeuten) bedeutet,

20 mit der Massgabe, dass in der obigen Definition die Fälle (i), wo A eine 4-Fluorphenylgruppe ist; B eine 4-Pyridylgruppe ist; R¹ eine Aminogruppe ist; und R² ein Wasserstoffatom ist, und (ii), wo A eine 4-Fluorphenylgruppe ist; B eine 4-Pyridylgruppe ist; R¹ eine Acetamidgruppe ist; und R² ein Wasserstoffatom ist, ausgeschlossen sind] oder ein Salz davon.

25 **2.** Verbindung mit der Formel:



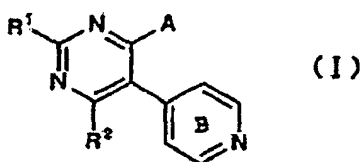
40 (worin A, R¹ und R² dieselben Bedeutungen wie in Anspruch 1 definiert haben; und B' eine 1,2-Dihydro-2-pyridinon-4-yl-Gruppe bedeutet, welche mit einer oder mehreren Gruppen substituiert sein kann, die ausgewählt sind aus einem Halogenatom, einer Hydroxylgruppe, einer C₁₋₆-Alkylgruppe und einer Aminogruppe) oder ein Salz davon.

- 45 **3.** Pharmazeutische Zusammensetzung, welche die Verbindung gemäss Anspruch 1 oder 2 oder ein Salz von diesen umfasst.
- 4.** Zusammensetzung gemäss Anspruch 3, welche ein Adenosin A_{2b}-Rezeptorantagonist ist.
- 5.** Zusammensetzung gemäss Anspruch 3, welche ein stuhlgangförderndes Mittel ist.
- 50 **6.** Zusammensetzung gemäss Anspruch 3, welche ein Mittel zur Behandlung, Vorbeugung oder Verbesserung von Verstopfung ist.
- 7.** Zusammensetzung gemäss Anspruch 3, welche ein Mittel zur Behandlung, Vorbeugung oder Verbesserung von funktioneller Verstopfung ist.
- 55 **8.** Zusammensetzung gemäss Anspruch 7, wobei die funktionelle Verstopfung spastische Verstopfung oder atonische Verstopfung ist.

9. Zusammensetzung gemäss Anspruch 3, welche ein Mittel zur Behandlung, Vorbeugung oder Verbesserung von Reizcolon oder Verstopfung, welche das Reizcolon begleitet, ist.
10. Zusammensetzung gemäss Anspruch 3, welche ein Mittel zur Behandlung, Vorbeugung oder Verbesserung organischer Verstopfung, Verstopfung, die enteroparalytischen Ileus begleitet, Verstopfung, die kongenitale Verdauungstraktdysfunktion begleitet, oder Verstopfung, die Ileus begleitet, ist.
11. Zusammensetzung gemäss Anspruch 3, welche zur Entleerung des Darmtrakts zum Zeitpunkt der Untersuchung des Verdauungstrakts oder vor und nach einer Operation dient.
12. Verwendung der in Anspruch 1 oder 2 beschriebenen Verbindung oder eines Salzes davon zur Herstellung eines stuhlgangfördernden Mittels.
13. Verwendung der in Anspruch 1 oder 2 beschriebenen Verbindung oder eines Salzes davon zur Herstellung eines Mittels zur Behandlung, Vorbeugung oder Verbesserung von Verstopfung.
14. Verwendung einer pharmakologisch wirksamen Menge der in Anspruch 1 oder 2 beschriebenen Verbindung oder eines Salzes davon zur Herstellung einer pharmazeutischen Zusammensetzung zur Förderung von Stuhlgang.
15. Verwendung einer pharmakologisch wirksamen Menge der in Anspruch 1 oder 2 beschriebenen Verbindung oder eines Salzes davon zur Herstellung einer pharmazeutischen Zusammensetzung zur Behandlung, Vorbeugung oder Verbesserung von Verstopfung.

Revendications

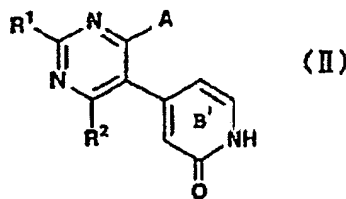
1. Composé représenté par la formule :



(dans laquelle A représente un groupe phényle, groupe pyridyle, groupe thiényle ou groupe furyle qui peut être substitué par un ou deux groupes choisis parmi un atome d'halogène, un groupe hydroxyle, un groupe alkyle en C₁₋₆, un groupe alcoxy en C₁₋₆ et un groupe (alcoxy en C₁₋₆)carbonyle ; B représente un groupe pyridyle qui peut être substitué par un ou plusieurs groupes choisis parmi un atome d'halogène, un groupe hydroxyle, un groupe alkyle en C₁₋₆ et un groupe amino ; R¹ représente un atome d'hydrogène, un groupe morpholinyle ou un groupe représenté par la formule -NR^{1a}R^{1b} (dans laquelle R^{1a} et R^{1b} sont identiques ou différents l'un de l'autre et chacun représente un atome d'hydrogène, un groupe alkyle en C₁₋₆, un groupe acyle en C₁₋₆, un groupe phényle ou un groupe (alkyl en C₁₋₆)sulfonyl) ; et R² représente un atome d'hydrogène ou un groupe représenté par la formule -NR^{2a}R^{2b} (dans laquelle R^{2a} et R^{2b} sont identiques ou différents l'un de l'autre et chacun représente un atome d'hydrogène ou un groupe alkyle en C₁₋₆).

à condition que, dans la définition précitée, les cas (i) où A est un groupe 9-fluorophényle ; B est un groupé 4-pyridyle ; R¹ est un groupe amino ; et R² est un atome d'hydrogène, et (ii) où A est un groupe 4-fluorophényle ; B est un groupe 4-pyridyle ; R¹ est un groupe acétamide ; et R² est un atome d'hydrogène soient exclus) ou un sel de celui-ci.

2. Composé représenté par la formule :



(dans laquelle A, R¹ et R² ont les mêmes significations que celles définies dans la revendication 1 ; et B' représente un groupe 1,2-dihydro-2-pyridinone-4-yle qui peut être substitué par un ou plusieurs groupes choisis parmi un atome d'halogène, un groupe hydroxyle, un groupe alkyle en C₁₋₆ et un groupe amino) ou un sel de celui-ci.

3. Composition pharmaceutique comprenant le composé selon la revendication 1 ou 2, ou un sel de celui-ci.
4. Composition selon la revendication 3, qui est un antagoniste du récepteur de l'adénosine A_{2b}.
5. Composition selon la revendication 3, qui est un agent favorisant la défécation.
6. Composition selon la revendication 3, qui est un agent destiné à traiter, prévenir ou améliorer la constipation.
7. Composition selon la revendication 3, qui est un agent destiné à traiter, prévenir ou améliorer la constipation fonctionnelle.
8. Composition selon la revendication 7, dans laquelle la constipation fonctionnelle est une constipation spasmodique ou une constipation atonique.
9. Composition selon la revendication 3, qui est un agent destiné à traiter, prévenir ou améliorer le syndrome de l'intestin irritable ou la constipation accompagnant le syndrome de l'intestin irritable.
10. Composition selon la revendication 3, qui est un agent destiné à traiter, prévenir ou améliorer la constipation organique, la constipation accompagnant un iléus paralytique, la constipation accompagnant un dysfonctionnement congénital du tube digestif ou la constipation accompagnant un iléus.
11. Composition selon la revendication 3, qui est destinée à évacuer le tractus intestinal au moment de l'examen du tractus intestinal ou avant ou après une opération.
12. Utilisation du composé décrit dans la revendication 1 ou 2 ou d'un sel de celui-ci pour produire un agent favorisant la défécation.
13. Utilisation du composé décrit dans la revendication 1 ou 2 ou d'un sel de celui-ci pour produire un agent destiné à traiter, prévenir ou améliorer la constipation.
14. Utilisation d'une quantité pharmacologiquement efficace du composé décrit dans la revendication 1 ou 2 ou d'un sel de celui-ci pour la fabrication d'une composition pharmaceutique destinée à favoriser la défécation.
15. Utilisation d'une quantité pharmacologiquement efficace du composé décrit dans la revendication 1 ou 2 ou d'un sel de celui-ci pour la fabrication d'une composition pharmaceutique destinée à traiter, prévenir ou améliorer la constipation.